Defence R&D Canada – Toronto : fact sheets

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Human Factors Research and Engineering Section

Objective:

To maximize the effectiveness of human-machine systems through the development and application of human engineering tools and methods.

Operations room in the Canadian Patrol Frigate.

Background

The optimal performance of today's complex military systems demands the full and effective use of both human and machine capabilities. The Human Factors Research and Engineering (HFRE) Section supports the requirements of the Canadian Forces (CF) through research and development in the following areas:

- human engineering tools and methods for the design, integration and evaluation of soldier systems and equipment;
- complex visual and 3-dimensional auditory displays; and
- noise and audio communications.

Organization

Three groups carry out the work of the HFRE Section:

- Human-Computer Interaction (HCI)
- Operational Human Engineering (OHE)
- Communications

Additional work is conducted through contracted-out activities.

Recent progress

HCI: Research contributed to the application of international standards for electronic chart information display systems. The effectiveness of 3-D audio displays under positive-G acceleration was confirmed.

OHE: A load carriage simulator was developed to permit rapid, objective assessment of load carriage systems and components. The effects of footwear inserts on comfort have been evaluated. Information requirements for dismounted infantry soldiers have been defined at the Section and Platoon level, using cognitive task analyses based on operational scenarios. Studies to improve night vision goggles are underway. User surveys on soldier system equipment contributed to the successful acquisition of the new Soldier's Helmet as well as a range of handwear and footwear under the Clothe the Soldier project.

Communications: Equipment was developed to allow members of ships' operations teams to converse among themselves while monitoring outside communications.

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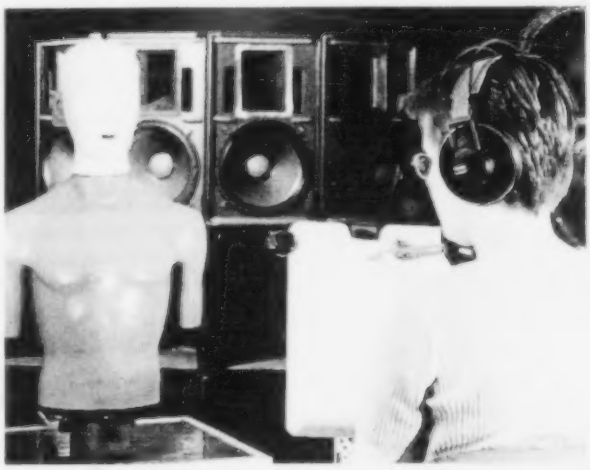
Human Factors Research and Engineering Section

Future directions

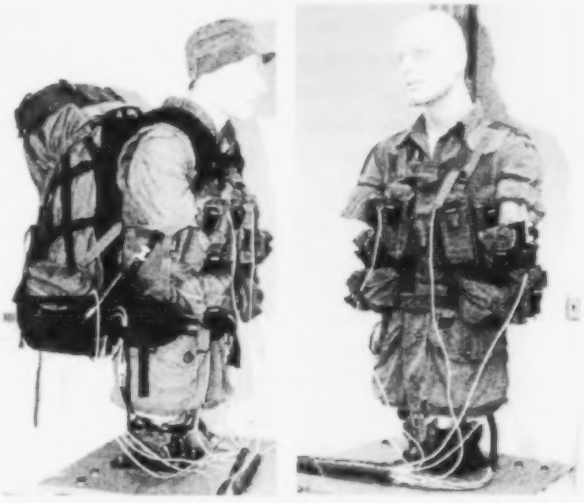
HCI: The integration of tactical and geographic information from different display sources will be studied. Research programs will be established in the display of complex data and in human attention to changes in complex displays. A robust human-system integration capability will be a priority.

OHE: A dynamic biomechanical model of human load carriage will be developed. Studies in footwear comfort will continue. Simulation or simple prototypes will be used to develop and analyze methods of providing information on command execution, target acquisition and situational awareness to soldiers. Future support for the Clothe the Soldier project will include user surveys, development of performance and technical specifications, and equipment evaluations. Development of the fragmentation protective vest and new load carriage system will be completed.

Communications: NATO round-robin testing of Active Noise Reduction (ANR) systems will be supported. Subject to resources, trials will be conducted on the effectiveness of ANR systems in the CC-130 Hercules aircraft.



Instrumented heads are used to test communications and hearing protection systems.



Load carriage simulators.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Operational Medicine Section

Objective:

To support Canadian Forces operational requirements by conducting research and development in combat casualty care, developing and applying protective clothing/equipment and physical training strategies, and assessing and preventing health hazards.

Protective equipment tests in DRDC Toronto's climatic chambers.

Background

Canadian Forces (CF) personnel are often required to work under harsh climatic conditions, and the modern battlefield presents a wide range of physical and chemical hazards. The provision of effective clothing, equipment and strategies for personal protection, and the delivery of health care to personnel engaged in operational deployments, are essential components of military preparedness and sustainability.

Novel strategies and advanced technologies are required to optimize the safety and effectiveness of personnel and to provide effective combat casualty care.

The Operational Medicine Section supports these requirements through research and development (R&D) in the following areas:

- novel therapeutic modalities and medical intervention methods;
- diagnostic/prognostic indicators and non-invasive medical monitoring systems;
- equipment and strategies for enhancing human protection and performance in adverse environments; and
- effective measures to monitor, assess and prevent occupational health hazards.

Organization

Four groups carry out the work of the Operational Medicine Section:

- Trauma Group
- Health Hazards Group
- Human Protection and Performance Group
- Biomedical Engineering Group

Additional work is conducted through contracted-out activities.

Recent progress

Trauma: Research is directed at improving combat casualty care. Focus areas include resuscitation strategies, blood and vital fluid replacement, hemorrhagic shock management, sepsis therapy, wound care and drug delivery.

Operational Medicine Section

Health hazards: Recommendations based on studies of biomedical and toxicological aspects of health hazards in operational environments have resulted in improved occupational health and safety in the CF.

Human protection and performance: The Improved Environmental Clothing System provides soldiers with superior protection against weather conditions and thermal stress. New techniques have been developed to provide rapid improvements in aerobic fitness and muscular endurance. Other studies examined the effect of ergogenic aids on physical performance, and how training, fitness, acclimation, state of hydration and gender affect heat tolerance. Computer models that predict survival times are now being used as decision aids by Search and Rescue personnel.

Biomedical engineering: Research activities have focused on developing field-deployable, noninvasive medical monitoring and imaging systems.

Future directions

Trauma: R&D efforts will be directed at developing resuscitative and therapeutic modalities to meet operational medical requirements for the CF. Research programs will be developed to facilitate the development of far-forward diagnostic capabilities and resuscitative strategies. Future work will be targeted at improving vital fluid replacement, resuscitation and post-surgical care, shock management and combat wound treatment.

Health hazards: Current capabilities in monitoring the atmospheric quality of confined spaces will be used to assess potential health risks. New initiatives include an expert team to assess risks in the field and R&D in biological indicators of toxicity.

Human protection and performance: Clothing with vapour-permeable membranes will be examined for heat and moisture transport. The feasibility of personal cooling for soldiers will be studied, and the benefits of auxiliary heating on hand motor performance will be quantified. Further studies of training methods and ergogenic aids, including field trials, are planned. The predictive model for cold exposure will be refined to account for heat production from physical activity and the effects of fatigue and malnutrition.

Cellular and molecular analyses by flow cytometry.

Biomedical engineering: Major initiatives are moving forward to develop robust and compact non-invasive imaging systems for the diagnosis of internal injuries in the field. Innovative signal-processing technology will be applied to reduce motion-associated artifacts and to produce 3-D tomographic visualization of traumatized internal organs and abnormalities.

For more information

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Head, Trauma Group
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Head, Health Hazards Group
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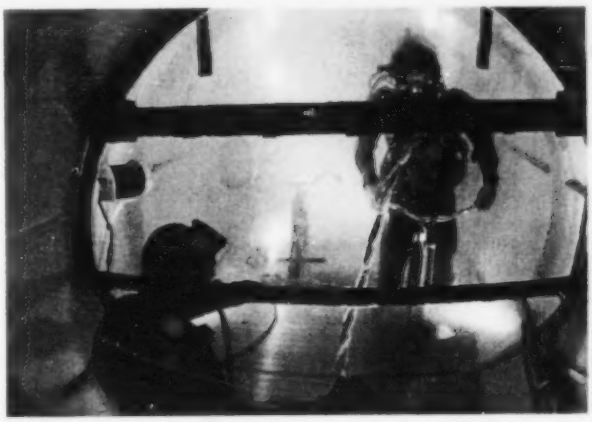
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Experimental Diving Unit

Objective:

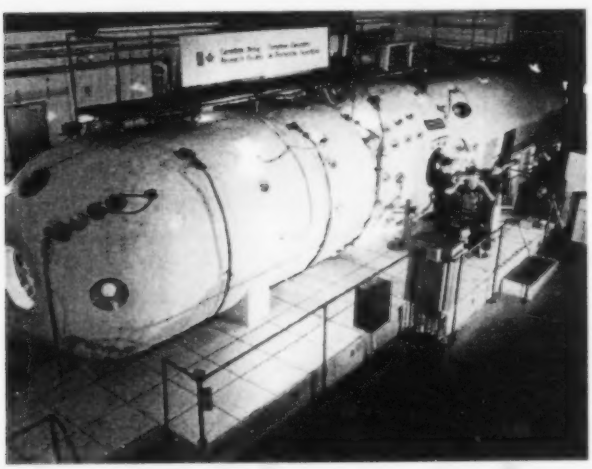
To ensure the operational capability of Canadian Forces diving and underwater intervention through research and development, training, and support of accident investigations.



Photograph by Cpl J. Clark, DRDC Toronto

Background

DRDC Toronto's Experimental Diving Unit (EDU) conducts research and development (R&D) in direct support of the Canadian Forces (CF) underwater capability. EDU's efforts help ensure diver safety as well as the security and availability of the fleet, selected army units and search and rescue operations.



DRDC Toronto's Diving Research Facility.

EDU's work includes the development and acquisition of diving equipment; the development of procedures and tools to enhance the safety and effectiveness of diving operations; and the integration of divers and unmanned systems. Equipment evaluation and the forensic investigation of diving accidents are enabled through DRDC Toronto's unique hyperbaric facilities.

Organization

Two groups carry out the work of the Experimental Diving Unit:

- Diving Operations Group
- Diving R&D Group

Additional work is conducted through contracted-out activities.

Recent progress

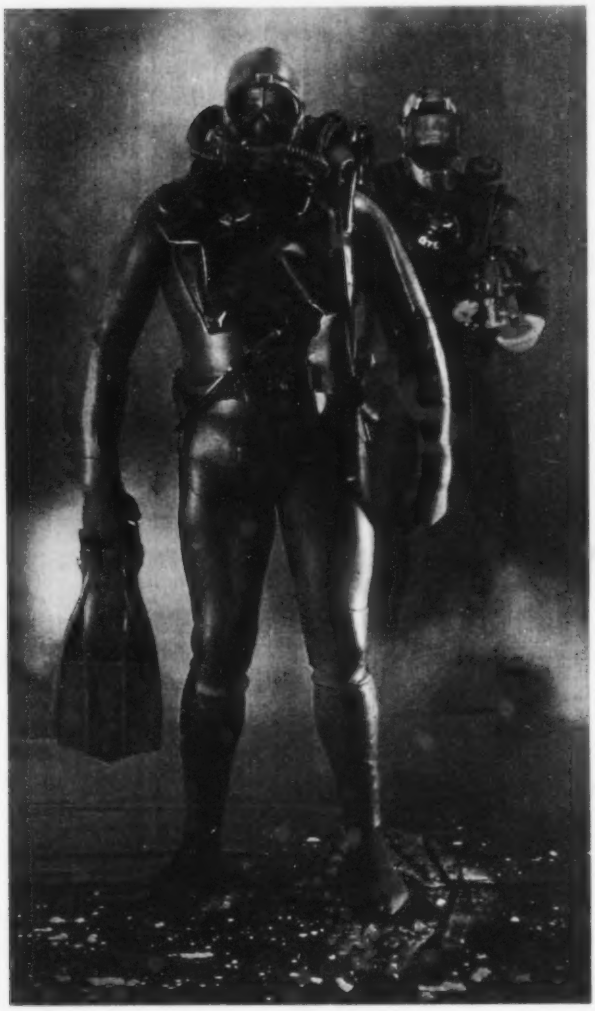
Diving procedures: Air and mixed-gas diving procedures, developed by EDU for the CF, have been adopted by over 40 other sport, military, and commercial diving organizations.

Clearance diving equipment: The Canadian Clearance Diving Apparatus (CCDA) and Canadian Underwater

Experimental Diving Unit

Mine-countermeasures Apparatus (CUMA), in service with the CF and several other foreign navies, were developed at DRDC Toronto.

Hyperbaric facility operations: EDU operates and maintains the largest and most capable hyperbaric facilities in Canada.



Canadian Underwater Mine-countermeasures Apparatus (CUMA).

Expertise: EDU has a long-standing tradition of support through multinational information exchange agreements. Personnel collaborate with military and civilian defence personnel in operational CF teams, Canadian industry, other government departments, and with international counterparts.

Future directions

Equipment: Work is continuing on protection for CF divers in contaminated and cold waters, and the further development of mine countermeasures systems. Alternatives and supplements to divers, such as robotics and underwater vehicles, are also being investigated.

Procedures: EDU is completing the development of decompression tables for CUMA, and investigating factors critical to effective work-up schedules for divers.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Aerospace Life Support Section

Objective:

To enhance the operational effectiveness and safety of Canadian Forces aircrew during exposure to the stresses of the aerospace environment.

Components of the STING advanced anti-G system were used by Canadian pilots flying CF-18 jets in Kosovo.

Background

The physical aerospace environment remains a major threat to flight safety and the completion of operational missions. Air operations can expose Canadian Forces (CF) aircrew to extremes of temperature, noise, vibration, motion, acceleration and altitude. Other hazards include laser, water immersion, fire/smoke, disorientation and impact. The Aerospace Life Support (ALS) Section contributes to the effectiveness and safety of CF aircrew through research and development (R&D) in aerospace physiology and the design and development of advanced protective equipment and performance enhancement strategies.

Organization

Two groups carry out the work of the ALS Section:

- Life Support Equipment Group
- Aircrew Performance/Protection Group

Additional work is conducted through contracted-out activities. As well, an ALS team provides support for air accident investigations.

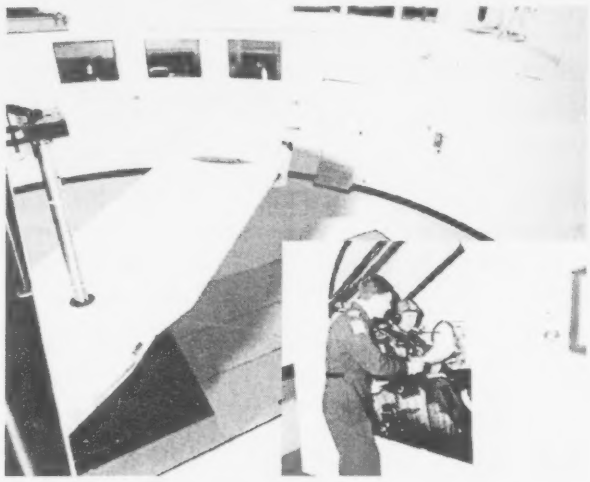
Recent progress

Life Support Equipment: Integration work with helmet-mounted life support equipment (e.g., night vision goggles) is ongoing. A new emergency breathing system for the Maritime environment has recently been introduced, and a new immersion suit has been developed.

Aircrew Performance/Protection: R&D has led to the development of advanced G-protection equipment for aircrew. Examples are the new CF-18 digitally-controlled anti-G valve and the STING (Sustained Tolerance to INcreased G) pressure garments and breathing system. Research in spatial disorientation (SD) has led to an improved understanding of SD as a factor in aircraft accidents.

Air Accident Investigations: An ALS team provides on-site consultation and post-investigation reviews of the human factors and survivability aspects of air accidents in support of the Directorate of Flight Safety.

Aerospace Life Support Section



DRDC Toronto's human centrifuge.

DRDC Toronto's Integrated Physiological Trainer (GYRO-IPT) is used to demonstrate spatial disorientation.

Future directions

Life Support Equipment: ALS will monitor and capitalize on commercial developments while maintaining a core capability to support aircrew in the field.

Aircrew Performance/Protection: Integrated adaptive life support systems ("smart" garments) will be investigated to optimize customized protection for aircrew. Other research will focus on the mechanisms of spatial orientation/disorientation and the design of improved ground-based training.

Air Accident Investigations: A human factors air accidents database is under ongoing development.

For more information

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Head, Aircrew Performance/Protection Group
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DEFENCE R&D DÉFENSE

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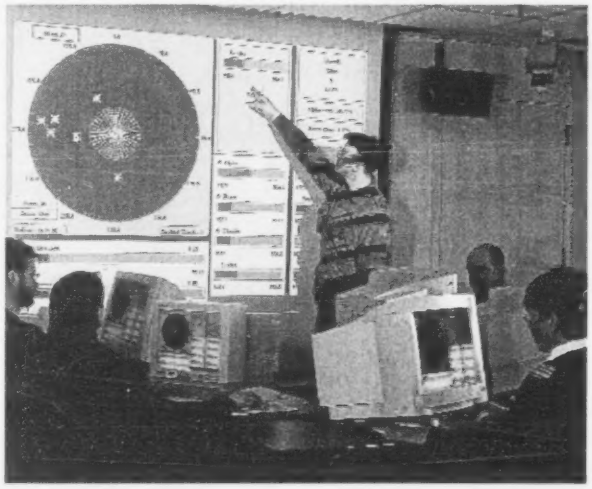
Command Effectiveness and Behaviour Section

Objective:

To conduct exceptional research into the operational, psychological, sociological and organizational factors that influence human behaviour and performance in the accomplishment of Canadian Forces missions.



Background

Whether involved in disaster relief, peacekeeping operations or war, the Canadian Forces (CF) deal in human adversity. CF leaders must make difficult split-second decisions, often under severe stress, that require policing, diplomatic and conflict-resolutions skills. The Command Effectiveness and Behaviour Section (CEB) conducts research to assist the CF in finding human solutions to human problems. Its product is scientific knowledge that influences CF doctrine, concepts, policies, education and training.

Organization

The CEB section comprises three scientific groups:

- Judgment & Decision Making (J&DM)
- Stress & Coping (S&C)
- Leadership & Trust (L&T)

Technical assistance is provided by the Support Group.

Recent progress

Judgment & Decision Making: Numerous experiments have been conducted to examine the use of heuristics in naturalistic decision-making contexts. Qualitative theories of confidence in human judgment are being tested, as are recognition-based decision processes.

Stress & Coping: A model of psychological adaptation across the deployment cycle of CF personnel has been developed. Predeployment adaptation questionnaires have been administered, and the initial analyses of adaptation during the predeployment phase of operations are complete. A deployment adaptation questionnaire is being developed. Members of the S&C group are part of a Canadian Forces Medical Services (CFMS) team exploring the role of psychological factors in deployment stress, health and well being over the course of a CF career.

Leadership & Trust: An initial investigation of leadership theories and models was completed, and a concept of leadership within the framework for command and control has been developed. A series of lectures on command was delivered to CF officers in order to spread awareness of the Pigeau-McCann C2 framework. The framework was used to analyze command

Command Effectiveness and Behaviour Section

Members of the Stress and Coping Group support Canadian Forces personnel by conducting research into the role of psychological factors in deployment stress, health and well-being.

challenges actually faced by the CF in order to assess its validity. A model of trust in small teams was developed, and an extensive review of the literature on trust in automation has been compiled.

Future directions

Judgment & Decision Making: Studies will investigate the effects of scenario context on confidence in the assessment of threat. Team-based experiments will focus on improving the Operational Planning Process. Situation awareness and recognition-primed decision-making will be examined.

Stress & Coping: Empirical testing of the psychological adaptation model is planned. A CF recruit questionnaire will be developed in conjunction with the CFMS team investigating deployment-related health issues. Questionnaires will be developed for the CF on the issues of post deployment reintegration and risk taking, and for the Ontario Provincial Police on stress.

Leadership & Trust: A series of CF-specific approaches to leadership will be developed in collaboration with the CF Leadership Institute. Clarification of the factors and mechanisms influencing the sharing of intent will be included in the C2 framework. Work will continue on the analysis of command challenges. A large-scale study will be conducted on perceptions of command capabilities. Direct and implicit measures of trust in small teams will be established.

For more information

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DEFENCE R&D DÉFENSE

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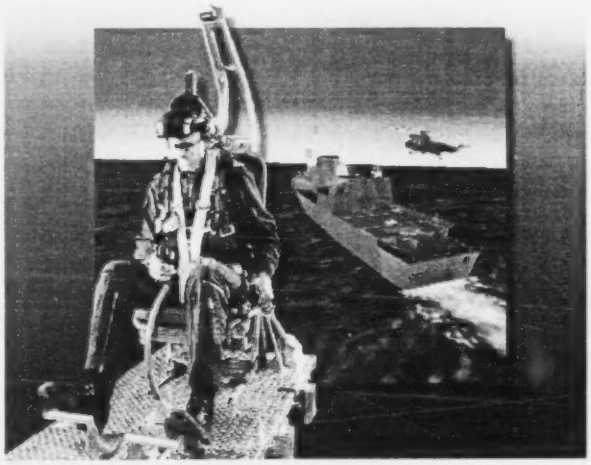
Simulation and Modelling for Acquisition, Rehearsal and Training Section

Objective:

To apply and advance human factors knowledge and techniques in the exploitation of modelling and simulation for equipment acquisition, training and mission rehearsal.



Helicopter Deck-Landing Simulator.

Background

Modelling and simulation are becoming increasingly important as tools and processes for reducing the costs and increasing the effectiveness of military acquisitions, training and mission rehearsal. As the international environment becomes less stable and warfare increases in technical sophistication, a greater reliance will be placed on training and simulation technologies that include humans in the loop. The Simulation and Modelling for Acquisition, Rehearsal and Training (SMART) Section conducts research and development (R&D) in support of Canadian Forces (CF) requirements for advanced concepts in materiel acquisition and distributed interactive simulation for collective training.

Organization

Two groups carry out the work of the SMART Section:

- Human Modelling Group
- Training Technology Group

Additional work is conducted through contracted-out activities.

Recent progress

Integrated Performance Modelling Environment (IPME): A human engineering tool used for mission, function and task analysis, IPME is the result of a collaborative development effort between the United Kingdom (DERA-CHS) and Canada (DRDC Toronto). IPME produces a simulated timeline of human/machine activities and predicts operator workload and performance. It incorporates a human information processing model and is capable of interacting with other models and simulations.

LOCATE: A computer-based design aid for workspace layouts, used to model the effectiveness of human-machine communications in visual, auditory, tactile and movement domains.

Intelligent Clothing and Equipment Sizing System (ICESS): A camera-based, digital system for accurately determining clothing and equipment sizes for CF

Simulation and Modelling for Acquisition, Rehearsal and Training Section

personnel. The system has great potential for reducing the costs of issuing clothing and equipment.

Aircraft Crewstation Demonstrator (ACD): A fixed-based, interactive simulator for analyzing cockpit technologies and crew interactions in fixed and rotary wing aircraft. It features an out-of-the-window display and uses rapid virtual prototyping technologies to simulate instrument panels. It was recently used to assess the efficacy of direct voice input for helicopter control.

Helicopter Deck-Landing Simulator (HDLS): This moving-base, interactive simulator demonstrates the exploitation of virtual reality and commercial off-the-shelf technologies to train demanding military tasks. It is being developed to train Sea King helicopter pilots to land aboard a Canadian Patrol Frigate in difficult conditions.

Dismounted Infantry Simulator (DIS): This simulator, which employs a head-mounted display and sensors that track body movements, provides the means to examine the human interface to synthetic environments. It is being used to assess methods for training small teams to work together in a virtual environment, while the team members are physically separated by large distances.

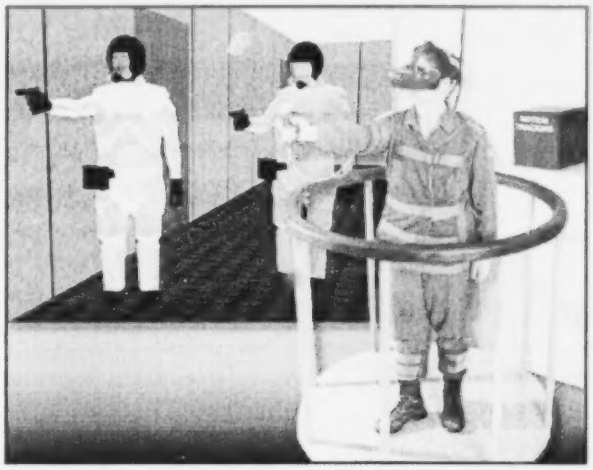
Future directions

The Section will advance IPME and ICESS capabilities in modelling the human form and individual/team behaviour for use in anthropometric analysis, workspace design, workload assessment, training and mission rehearsal.

The ACD will be used to examine means for enhancing situational awareness. The HDLS will be incorporated in a federation of simulators for training the Officer-of-the-Watch, Landing Signals Officer and Flight Deck Control Officer of a Canadian Patrol Frigate.

The generic foundation of the HDLS will be used to represent other helicopter types and train emergency touchdown procedures.

The development of the DIS will be harmonized with the Soldier Information Requirements (SIREQ) Technology Demonstration project to assist in equipment acquisition.



Dismounted Infantry Simulation.

Jointly with the US Air Force Research Laboratory, Section staff will develop visual display system technology and simulations for the Advanced Distributed Mission Training (ADMT) Technology Demonstration project.

Other work will address the best mix of simulator and in-flight training for CF-18 pilots and human factors issues in long-distance simulation.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Medical Assessment and Training Section

Objective:

To conduct specialized medical assessments, provide expert medical case reviews and offer operational medical training in support of Canadian Forces (CF) requirements.

Background

The military operational environment demands members who are physically and mentally fit for their duties. New candidates wishing to serve as aircrew must be carefully screened prior to acceptance for training. Likewise, serving members wishing to become CF divers undergo a screening process to determine their fitness prior to starting training. Aircrew or divers who develop medical conditions that could compromise their operational effectiveness must also be assessed. Specialized training is required for medical and support personnel working in the aerospace and diving environments. The Medical Assessment and Training Section (MATS) supports CF requirements in these areas by offering a broad variety of specialized medical services and facilities.

Organization

MATS is part of the Canadian Forces Environmental Medicine Establishment (CFEME), the military component of DRDC Toronto. MATS comprises two sub-sections:

- Medical Assessment Section (MAS)
- The School of Operational Medicine (SOM)

Medical test facilities include colour doppler and 2D echocardiogram.

MATS also operates the CF's Central Medical Board (CMB) and the Aeromedical/Environmental Consult Service.

Medical Assessment Section

MAS is responsible for evaluating the medical fitness and physical suitability of all CF aircrew candidates. The screening process includes detailed review of medical history as well as specific tests. Candidates for pilot and air navigator are seen during their week of selection process administered by the Aircrew Selection Center. Other aircrew candidates and candidates for clearance diving are normally evaluated through a review of their medical records. More detailed examinations are conducted if indicated.

Central Medical Board

When serving aircrew or divers develop a medical condition, their ability to carry out their duties may be

Medical Assessment and Training Section

Training includes environmental familiarization sessions in DRDC Toronto's facilities.

affected. The objective of CMB is to provide a central resource for the review of such cases. The Board consists of a panel of specialized medical officers, including pilot physicians, diving physicians and specialists in internal, occupational, aviation and diving medicine. CMB holds official meetings quarterly and holds extraordinary sessions as required. Recommendations from CMB are forwarded to 1 Canadian Air Division and to the Directorate of Medical Policy if needed.

Aeromedical/Environmental Consult Service

The specialized services and expertise available to CF personnel through CMB are also available to agencies and individuals outside the Department of National Defence. This service includes expert consultation in aviation and space medicine, diving medicine, and medical aspects of working in stressful environments (e.g., extreme heat, cold, or high altitude). This service provides access to internationally-recognized medical specialists, experts in human factors and senior CF divers, aviators and other operational personnel.

School of Operational Medicine

SOM has provided operational medicine training to CF personnel at its present location since the early 1970s. A broad range of training is offered, including aviation medicine, diving medicine and the physiology of high altitude and acceleration (G) forces.

The following courses are currently offered:

- Diving Medicine – Basic
- Diving Medicine – Advanced
- Diving Medical Technician – Basic
- Diving Medical Technician – Advanced
- Clearance Diving Officer/Clearance Diving Technician (Diving Medicine segment)
- Flight Surgeon Course

Students include physicians, biosciences officers, medical technicians, pilots, military and police divers and astronauts. Training is also provided to foreign military officers and civilians working in similar occupational environments. Training is provided through a mix of classroom lectures, case study discussions, environmental familiarization and visits to operational units. Lectures are delivered by in-house specialist staff and internationally renowned experts. All courses are revised and updated on a continual basis in order to meet current operational needs. All medical courses meet the requirement for Continuing Medical Education credits.

For more information

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DEFENCE R&D DÉFENSE

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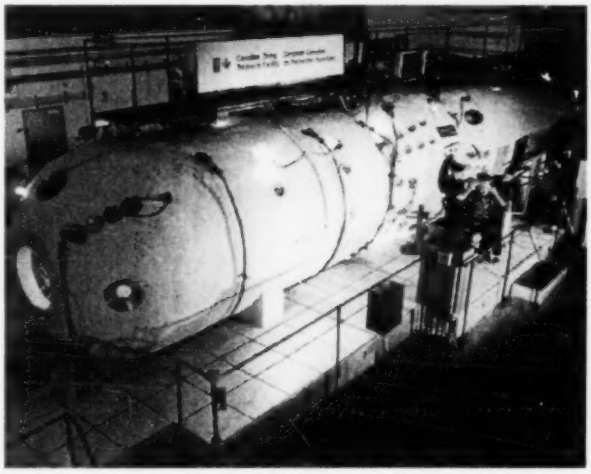
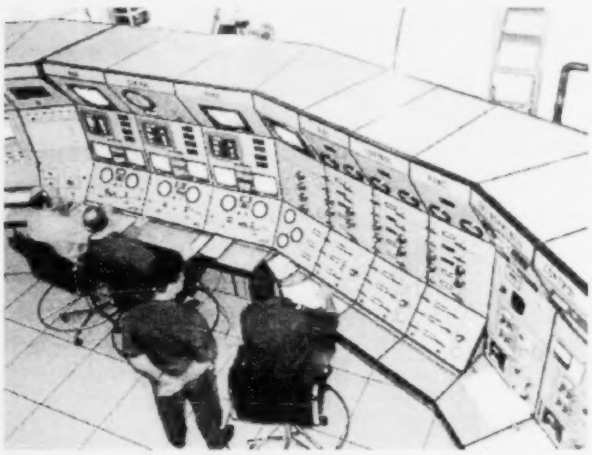
Diving Research Facility

The Diving Research Facility is a Canadian-designed and built deep-ocean simulator capable of being pressurised to over 1700 meters below sea level.



Background

Since its installation in 1978, DRDC Toronto's Diving Research Facility (DRF) has been used to further a broad range of national sub-sea research objectives for the Canadian Forces (CF) and other clients. Over 2100 manned and several hundred unmanned dives have been conducted for the CF, the Royal Navy, the Canadian Space Agency, Atomic Energy of Canada Ltd, and commercial clients such as Off-shore Systems Engineering Ltd and Fullerton Sherwood Engineering Ltd (now a division of Carlton Life Support Technologies).



Diving operations are directed and monitored using a state-of-the-art control panel.

Facts and figures

The DRF was designed as a saturation diving complex. It can accommodate four personnel for saturation dives and as many as 26 for "bounce" dives. The DRF is normally pressurized with compressed air but may be dived with helium or other pure gases. Its Built-in Breathing System (BIBS) – a series of breathing gas manifolds – can be used to deliver specialized breathing mixtures or in emergencies.

The DRF pressure hull consists of three independent but interconnected chambers:

- The *diving chamber* (7.3 m long x 2.4 m dia.) is used for underwater tests of equipment and procedures. Approximately half of this chamber is flooded with fresh water (over 20,000 litres) which can be chilled to temperatures as low as 3°C to simulate Canadian underwater marine and estuarine environments.
- The *living chamber* (6.4 m long x 2.4 m dia.) contains bunks, a fold-away eating area and provision for entertainment video. Doppler monitoring equipment allows scientists and medical

Diving Research Facility

personnel to monitor the divers' decompression stress during the dive.

- The central *transfer sphere* allows personnel to enter and exit the DRF while the living and diving chambers remain at depth. It contains a sink, shower, and toilet.

Each chamber has an equipment/medical lock to enable the transfer of diving equipment, food and medical supplies while the chamber is at depth. A multiple-channel communications system provides two-way voice communications with all three chambers. The system also provides entertainment audio and a helium voice unscrambler.

Applications

Procedures: The DRF was used to validate the DCIEM/CF Air and HeO_2 Diving Decompression Tables, which are in wide use among sport, commercial, and foreign military divers.

Equipment: The DRF has been used in the development of:

- Canadian Underwater Mine-countermeasures Apparatus (CUMA), a specialized breathing apparatus which enables CF divers to neutralize influence-type sea mines
- new non-freezing divers' breathing regulators for Canadian cold water operations

In 1994, the DRF was used by the Canadian Space Agency for a simulated space mission. Four Canadian astronauts – Mike McKay, Dave Williams, Julie Payette and Robert Thirsk – spent a week of isolation in the chamber.

The diving chamber is used to test diving equipment and procedures.

- active heating for Mine Countermeasures (MCM) divers
- the CF MCM diving system, including weight-vests, lighting, navigation, and diver information displays
- a contaminated water diving ensemble for CF divers

Future activities: The DRF will be used for research in pressure acclimatization, development of a non-freezing scuba regulator, and application of probabilistic (predictive) models of decompression.

Availability

The DRF is available under memoranda of understanding to other national governments and government agencies or under contract to civilian and commercial organizations.

For more information

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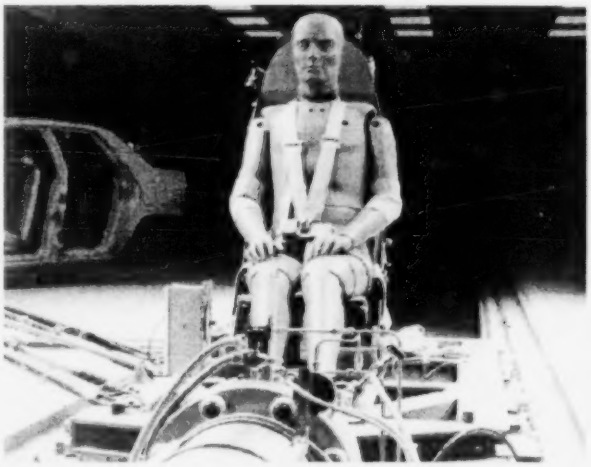
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

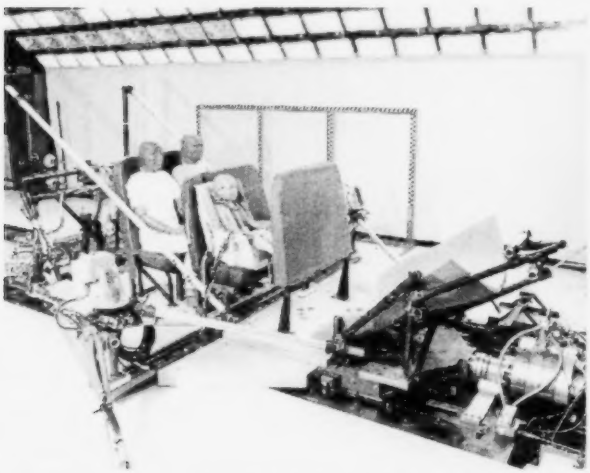
Impact Studies Facility

The Impact Studies Facility uses a Bendix HyGe Crash Simulator System to investigate and improve the impact performance of restraint and occupant seating systems in air and ground vehicles.



Background

The Impact Studies Facility (ISF) is the only facility of its kind in Canada. Since its installation in 1980, it has been used for more than 4000 simulated impacts for 50 commercial and government agencies. Tests carried out at the ISF help commercial and government agencies develop new restraint devices and ascertain compliance with motor vehicle safety standards.



Mock-ups of school bus seats are used to study the interaction of occupants with seats/barriers.

Facts and figures

The HyGe System can simulate impacts accurately, consistently, and economically. The maximum payload is 2270 kg (5000 lbs) with maximum decelerations and velocities of 60 G and 100 km/h (60 mph) respectively. Specialized bucks and unusual platforms can be accommodated on the sled.

Data collection: A computer-based processing system collects data at 10,000 samples per second from an array of 96 transducers, and performs filtering according to SAE J211 (SAE Impact Recommended Practice).

Data analysis: A number of high-speed video and movie-film cameras, as well as a state-of-the-art target-tracking facility, are used to facilitate the measurement of payload motions. Rapid turnaround of results is guaranteed via digital data/video recording and electronic delivery.

Impact Studies Facility

Applications

Compliance with safety standards:

- Compliance testing for Transport Canada (yearly) and commercial agencies (on request) to Canadian Motor Vehicle Safety Standards (CMVSS 213, 213.1, and 213.2) of all child and infant carriers sold in Canada.
- Compliance testing of child and infant carriers to US safety standards (FMVSS 213), including knee excursion and Head Injury Criterion calculations.
- Assistance to Transport Canada in the development of new standards for child carriers and other restraint devices.

Restraint devices:

- Assistance to commercial and government agencies through compliance testing and the development and evaluation of child and infant carriers.
- Assistance in the development and evaluation of other impact restraint aids, such as wheelchairs, ambulance cots, specialized van chairs and bench seats, and custom-made carriers for the handicapped.

The ISF can also be configured for non-standard investigations (e.g. using automotive body-bucks, bus floors, aircraft cockpits/seats, etc.) with extensive and flexible camera coverage.

Availability

The ISF is available under memoranda of understanding to other government agencies or under contract to civilian and commercial organizations.

The Bendix HyGe Crash Simulator System is ideally suited to the development and compliance testing of new child restraint systems.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

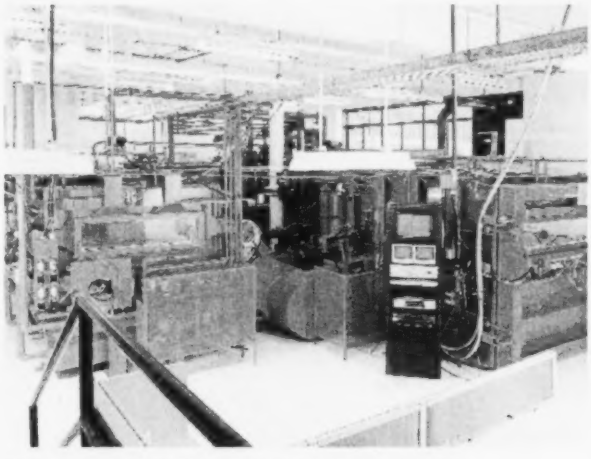
Hypobaric Facility

The Hypobaric Facility is a high-altitude simulator used for aeromedical training, research, medical assessment and equipment development.

Background

Canadian Forces (CF) aircrew frequently work in high altitude environments where the supply of oxygen is essential for life support. To ensure personal safety and operational effectiveness, aircrew must be able to recognize the symptoms of insufficient oxygen (hypoxia) and take appropriate action. Training in the effects of altitude on human physiology, and familiarization with hypoxia, is required for all CF aircrew as well as others exposed to high altitudes.

Since 1957, DRDC Toronto's Hypobaric Facility has allowed personnel to safely experience the symptoms of hypoxia in a controlled environment, under the supervision of aeromedical instructors. The facility is used for research, medical assessment and equipment development as well as training.



The Hypobaric Facility was refitted in 2000 with new mechanical systems.

Facts and figures

The Hypobaric Facility consists of an 5.5 x 2.5 metre (18 x 8 ft) main chamber, seating up to 16 students and two observers, and a small satellite chamber that accommodates one subject plus an observer.

The main chamber can be used for both "slow" decompressions (those taking 15 seconds to decompress to 18,000 feet) and "rapid" decompressions (taking less than one second to decompress to 10,000 feet). Both chambers are capable of reaching a simulated altitude of over 100,000 feet in less than five minutes.

The Facility was refitted in 2000 with new vacuum pumps and larger vacuum lines, a closed circuit television system, fire suppression system, and upgraded air conditioning and pneumatic systems.

Hypobaric Facility

Applications

Training: The main chamber is used for high altitude physiological training and hypoxia familiarization for a wide variety of personnel including military and civilian aircrew, Canadian Space Agency personnel preparing for NASA flights, flight surgeons and aeromedical personnel.

Research: Research projects conducted in the Hypobaric Facility include the development of advanced life support systems incorporating positive pressure breathing technology. Studies of the effects of altitude-induced hypoxia on human physiology and performance have also been conducted.

Medical assessment: The Hypobaric Facility has been used for diagnostic assessments of medically-restricted aircrew, including doppler monitoring of CF aircrew to assess susceptibility to altitude-induced decompression illness.

Other: Air sampling devices, for the detection of narcotics and explosives, have been tested in the Hypobaric Facility. The main chamber has also been used to dry waterlogged papers.

Availability

The Hypobaric Facility is available under memoranda of understanding to other government agencies or under contract to civilian and commercial organizations.

The satellite hypobaric chamber is used for the development of advanced life support systems.

For more information

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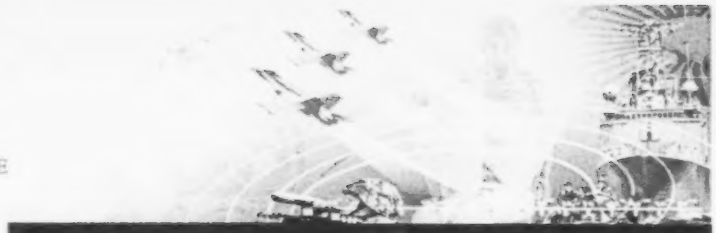
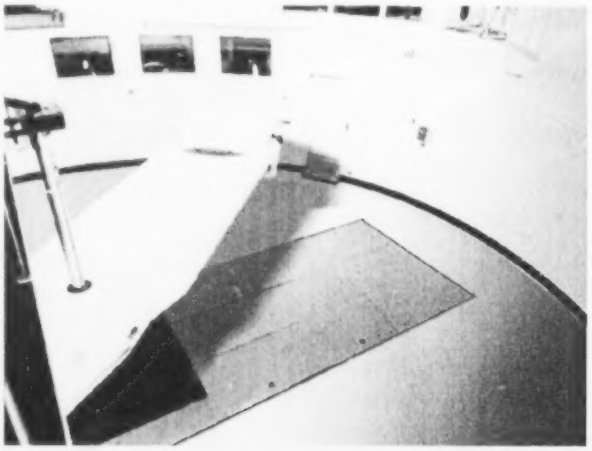


Defence R&D Canada – Toronto

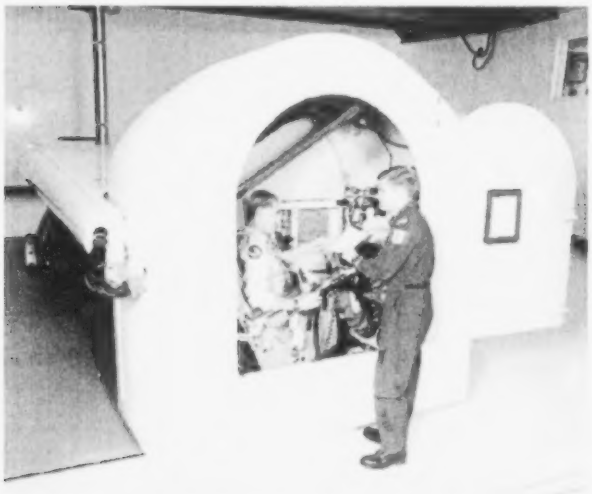
Human Centrifuge

The Human Centrifuge simulates the rapid-onset G-forces experienced by Canadian Forces pilots flying high performance aircraft.



Background

High G-forces experienced by pilots of jet aircraft such as the CF-18 decrease blood pressure in the head. This can lead to loss of vision and sometimes loss of consciousness. DRDC Toronto's human centrifuge, the only facility of its type in Canada, has been used since 1988 for research, training, medical evaluation, and equipment development.



Centrifuge riders are briefed on procedures prior to exposure to G forces.

Facts and figures

G-forces are expressed relative to the force of gravity (1 G). The centrifuge can generate from 1.4 to 15 G, at onset rates up to 4 G/sec, and for durations up to several minutes. The free-swinging gondola, which takes payloads up to 320 kg, is equipped with aircraft-type seat and pressurized life support equipment, a rider-operated enable switch, and two-way audio communication. Video display and biomedical instrumentation are used to monitor the centrifuge rider. G-run profiles and data acquisition are controlled by computer. The G profiles can follow instructions from a library of predetermined profiles or can follow the movement of the control stick as the centrifuge rider chases a target on a monitor.

Applications

Research: Current research projects in the centrifuge include:

- respiratory muscle training for improving anti-G straining maneuvers;

Human Centrifuge

Technicians and medical personnel closely monitor all centrifuge sessions.

- the effect of repetitive G exposure on G-tolerance; and
- bio-sensor and microprocessor-controlled aircrew life support equipment.

Previous research improved fighter pilot G protection with new anti-G suits and the introduction of positive pressure breathing.

Training: Through training sessions in the centrifuge, Canadian Forces (CF) jet pilots learn how high G-forces impair vision and how to combat this effect using muscular anti-G straining manoeuvres.

Medical evaluation: The centrifuge can be used to simulate in-flight G-exposure in personnel undergoing medical assessment.

Equipment development: A new digitally-controlled G-valve for pressurizing anti-G suits has been developed under contract.

Availability

The Human Centrifuge is available under memoranda of understanding to other government agencies, under collaborative agreements with research institutions such as universities, or under contract/partnership arrangements with civilian and commercial organizations.

Subject in centrifuge gondola at high Gz.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Climatic Facility

The Climatic Facility includes four chambers used to simulate environmental conditions from Arctic cold to tropical heat/humidity, and a human water calorimeter used to measure heat loss.

Background

Canadian Forces (CF) personnel on deployment can face temperatures from the cold Arctic regions of northern Canada to the hot deserts of the Middle East. Specialized clothing is necessary in these extreme environments to allow military operations to proceed with minimal disruption.

DRDC Toronto's Climatic Facility includes four chambers used to conduct research in human thermal physiology and to develop and evaluate protective clothing and equipment. Two large chambers, constructed in 1992, are supplemented by two smaller chambers. The Facility also includes a human water calorimeter – the only device of its kind in North America. The calorimeter is used to precisely measure human heat loss through whole-body immersion in water.

The new North American wind chill index was developed by DRDC Toronto scientists and validated in the climatic chambers.

Facts and figures

The two large climatic chambers (Dry/cold and Tropical wet/cold) are equipped with state-of-the-art computer data acquisition systems for recording human physiological responses to environmental stress. Each accommodates up to six subjects exercising on treadmills. Separate ante-chambers are available for subject preparation and blood sampling. A central control room includes on-line physiological monitoring equipment. A communication system permits staff to communicate with personnel inside the chambers.

Dry/cold chamber: Used to simulate conditions from Arctic dry cold to temperate. Temperature range is -50°C (-58°F) to 25°C (77°F), with wind speeds up to 36 km/h (23 mph).

Tropical wet/cold chamber: Used to simulate conditions from the wet and cold of northern coastal

Climatic Facility

The Human Water Calorimeter is used to test new immersion suits for the CF.

Europe to the heat and humidity of tropical rain forests or the hot dry deserts of equatorial latitudes. Temperature range is 2°C (35°F) to 60°C (140°F). Relative humidity can be set at 10–90%.

Smaller chambers: These two chambers have an effective temperature range of -25°C (-13°F) to 45°C (113°F). Humidity can be controlled at temperatures above freezing.

Human water calorimeter: The calorimeter works on the principle of constant water temperature to measure the heat lost or gained (within one watt) by the human body. A computer-controlled heat exchanger loop maintains the temperature of the 1200 litres of water in the tank to within 0.01°C of the set point, in water temperatures ranging from 3 to 50°C.

Applications

Clothing and equipment: The Climatic Facility has been used in the development and/or evaluation of:

- a new CF cold weather clothing system that protects against wind, rain, and snow from +10°C to -40°C using only three layers of clothing
- sleeping bags and tents for Arctic use
- a new concept in nuclear, biological and chemical (NBC) defence clothing to reduce heat stress
- a commander's guide for NBC operations in hot environments
- improved personal cooling garments such as those used in the Gulf war
- total microclimate conditioning garments that include both auxiliary heating and cooling
- new Arctic diving ensembles for CF divers
- immersion suits for prevention of accidental immersion hypothermia
- athletic and special purpose clothing for private industry
- validation of heat flux transducers for the measurement of total body heat loss in water
- calibration of thermal manikins

Physiological research: The climatic chambers have enabled our scientists to enhance their understanding of the effect of factors such as aerobic fitness, body composition and hydration on heat tolerance when protective clothing is worn. The chambers have also been used in studies to re-evaluate the windchill index. The calorimeter has been used to test new thermogenic drugs and treatments for improving resistance to cold, to evaluate standard drugs used by the CF for their potential detrimental effects on body temperature, and to study cold physiology in channel swimmers. Research findings are used to improve the predictive accuracy of computer models of human thermoregulation.

Availability

The Climatic Facility is available under memoranda of understanding to other government agencies or under contract to civilian and commercial organizations.

For more information

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Chair, Calorimeter Committee
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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Operational Medicine Research Facility

The Operational Medicine Research Facility includes three laboratories with state-of-the-art equipment for flow cytometry, mass spectrometry and microbiological analysis. Two new laboratories are currently being established to support certified analytical work in industrial hygiene and toxicology.

Cellular and molecular analyses are performed by flow cytometry.

Background

DRDC Toronto's biomedical research program supports the operational requirements of the Canadian Forces (CF) Health Services Branch by conducting R&D to establish strategies for treating combat injuries as well as assessing and preventing operational health hazards.

Front-line fluid resuscitation and battlefield wound management are two of many trauma issues that need to be addressed to provide effective field support for combat casualty care. The simulation of contaminated war wounds requires laboratory analytical support in microbiology. An understanding of the pathophysiology and immunological complications of hypovolemic shock in penetrating trauma requires the use of flow cytometry for analysis at the cellular and molecular level.

Biomedical aspects of health hazards are studied under the mandate of the Force Health Protection Program. With facilities and expertise in mass spectrometry, toxicology, and industrial hygiene, DRDC Toronto is well-equipped to study hazardous contaminants, perform risk assessments, understand toxic injury mechanisms, and recommend strategies for prevention and intervention.

Laboratory facilities

Flow Cytometry

The laboratory currently includes a BD FACSCalibur Flow Cytometer and a BD FACScan Flow Cytometer. We routinely perform the following analyses:

- Cell Surface Markers
- Lymphocyte Functional Assays
- Intracellular Analyses
- Clinically useful markers
- Apoptosis and the Cell Death Pathway

Primary areas of research include the effects of physical and environmental stressors, hemorrhagic shock, blood transfusion or critical illness on immune reactivity, and the identification of potential prognostic and diagnostic markers to facilitate early intervention and treatment of critically ill CF personnel.

Operational Medicine Research Facility

Mass Spectrometry
Laboratory facilities as well as gas and liquid chromatographic and mass spectrometric equipment are used to identify and analyze drugs, drug metabolites, toxins, biochemical compounds and their metabolites, and potentially toxic chemicals from occupational environments, in biological fluids and tissues.

Microbiology
Equipment and facilities for general and physiological microbiology research include a sterilizer, water baths, shakers, incubators, ovens, a pH meter, and balances. Additional equipment includes a Class II laminar-flow hood, anaerobic chambers and a Dark-Field electronic register colony counter. Body fluids and tissue samples are routinely analysed in investigations of the pathological and physiological effects of infection in clinical conditions such as sepsis, burn injury and wound complications.

Planned facilities

Certified Industrial Hygiene Analytical Laboratory
This facility will provide the CF with an in-house laboratory for all its occupational hygiene needs. Through the provision of timely and cost-effective air/soil/water analysis, it will simplify the development and surveillance of exposure profiles for serving members.

Toxicology
This facility will be used to study the biological effects of chemical mixture exposures and identify diagnostic markers for use in personal detection devices. Equipment will include an inhalation exposure system, lyophilizer, centrifuge and a flow/fume hood.

Availability

The Operational Medicine Research Facility is available under memoranda of understanding to other government agencies, or under contract to civilian and commercial organizations.

Pharmaceutical grinding and particle sizing/analysis equipment.

Gas chromatography – mass spectrometry facility.

For more information

Flow Cytometry
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Microbiology
(416) 635-2165

Toxicology and Industrial Hygiene Laboratory
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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Noise Simulation and Modelling Facility

The Noise Simulation and Modelling Facility uses a reverbant chamber, instrumented heads and sound generation devices to explore the effects of noise on hearing and communications.

Background

The quality of communications in many Canadian Forces (CF) environments is degraded by excessive noise. To optimize communications effectiveness, equipment such as headsets, respirators and communications links must be evaluated under realistic operational conditions. Communications modelling – using mannequins and test fixtures that simulate breathing, speech and hearing – provides a practical, safe and cost-effective alternative to on-site testing involving human subjects. The accurate simulation of high-noise environments, when integrated with communications modelling, provides a comprehensive facility for acoustical performance evaluations. DRDC Toronto's noise simulation chamber has been used since 1953 for a variety of noise exposure, hearing conservation and communications activities.

Facts and figures

Noise Simulation Chamber: The noise simulation facility includes a spacious reverberant room (11 x 6 x 3m) for subjects and equipment, and a noise-shielded control room for experimenters. A library of 'military noises' is available to the user, and the chamber sound system is easily 'tuned' to accommodate new ones. Digital sound editing and numerical methods simplify the generation and presentation of test stimuli to subjects and the entry of response data into analysis routines. Dedicated monitoring and control systems promote subject safety. A recent upgrade permits the generation of infrasound that enables, for example, the faithful recreation of helicopter rotor noise.

Human Head Simulator (HHS): Developed for DRDC Toronto by the University of Toronto, the HHS is a breathing and voice simulation system coupled with a life-like headform. The voice system self-adapts to flow-restrictive equipment such as respirators. A recent upgrade permits the presentation of standard Diagnostic Rhyme Test speech lists to human listeners during the evaluation of communications links. The HHS may also be used with STIDAS (Speech Transmission Index Device using Artificial Signals), a computer-based system for the objective measurement of speech discrimination.

Binaural Auditory Simulator (BAS): The headform of this manikin is fitted with artificial ears that model the shape, texture and acoustical impedance of the human outer ear. The tympanic membranes are represented by

Noise Simulation and Modelling Facility

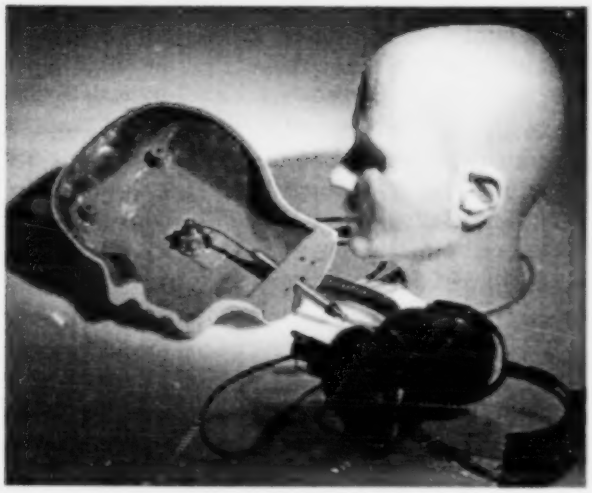
microphones that allow the acoustical characteristics of a variety of hearing-protective or communications equipment to be assessed. The binaural 'listening' capability of the BAS also benefits three-dimensional audio research done at DRDC Toronto.

Applications

Physical studies: The facility is used to evaluate communications equipment (e.g., noise-cancelling microphones, earphones, passive and active hearing protectors, respirators) and to measure the efficacy of acoustical fixtures and simulators for audition and voice. The STIDAS capability may be used where estimates of speech intelligibility are required. The facility allows communications systems to be exercised to their limits in noise environments typical of field operations, without risk to human subjects or the need for field trials.

Psycho-acoustics: Studies of human performance include measures of speech discrimination in noise using the Diagnostic Rhyme Test or the Modified Rhyme Test. Recently, a study to determine speaker-listener distances for male and female speech produced by the HHS in a background of ship operations room noise demonstrated that the female voice was intelligible over greater distances.

Equipment evaluations: A number of commercial



Internal microphones in the Binaural Auditory Simulator can "listen" to sound levels that would cause hearing damage in human subjects.

The Binaural Auditory Simulator is used to study headset intelligibility.

Active Noise Reduction (ANR) headsets were recently evaluated in the noise environment of a Sea King helicopter. Current work involves further ANR evaluation as DRDC Toronto's contribution to the work of an international consortium studying robust test methods for military ANR equipment.

Learning centre: The facility is a focal point for presentations and demonstrations.

Other applications: Aural non-detectability limits for military and security systems and equipment can be determined. The BAS can be used for determining the the noise attenuation of ear muffs and ear plugs. Mannequins are also used for headworn equipment fitting tests.

Availability

The Noise Simulation and Modelling Facility is available under memoranda of understanding to other government agencies, or under contract to civilian and commercial organizations.

For more information

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DEFENCE R&D DÉFENSE

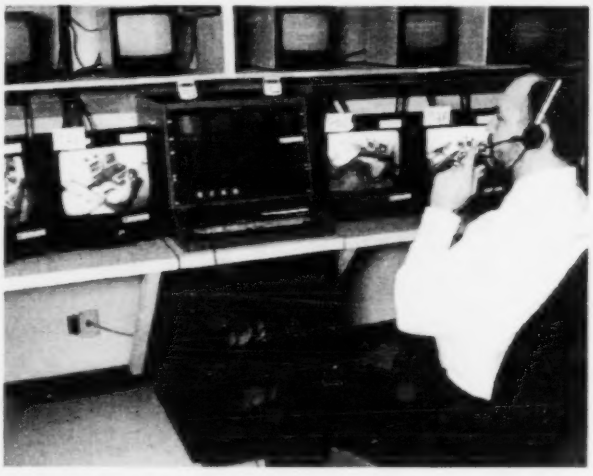
Defence R&D Canada – Toronto

Team Decision-Making and C2 Facility

The Team Decision-Making and C2 (TDMC2) Facility is a self-contained laboratory used to study individual and team decision-making in Command and Control (C2) situations.

Background

Canadian Forces (CF) operations frequently require personnel to work together while performing mentally demanding tasks under conditions of stress and uncertainty. Some tasks must be accomplished individually while others must be coordinated among team members to achieve maximum effect. Team members may work apart (i.e., distributed teams) and communicate through a medium (e.g., audio communication or computer network), or they may work in a common location (i.e., face-to-face teams). Team performance depends to a certain degree on individual-level performance; therefore, research into team decision-making cannot happen in isolation from research into individual decision-making. The TDMC2 facility, completed in 1994, is used to investigate both individual and team performance in situations analogous to military C2.



Fully-integrated control rooms are used by experimenters to monitor subjects and record behaviour.

Facts and figures

The TDMC2 Facility is a self-contained, windowless laboratory consisting of several rooms that can be configured to simulate conventional or distributed C2 headquarters (see illustration on next page). Four subject rooms allow individuals to work independently on unique tasks, or to share information using a computer network. The briefing room is used to simulate operations centres (e.g., on board a frigate). Two control rooms allow experimenters to monitor,

Team Decision-Making and C2 Facility

Briefing Room
- audio communication system
- large screen projector system
- pan zoom cameras

Kitchen
stove, fridge, microwave, dining area, dishes and sink

Control Rooms
equipped with computers, closed circuit video monitors and intercom system

Subject Rooms
each room is equipped with computers, beds, cameras and intercoms

record, and control all aspects of the studies. For example, behaviour can be videotaped using multiple cameras with pan and zoom capability, verbal communications can be stored and analysed, and a computerized task delivery and recording system allows continuous evaluation of mental performance. Electrophysiological data (e.g., EEG, ECG, respiration) can be recorded for comparison to cognitive performance measures. Complete kitchen and washroom facilities are available for extended studies.

Applications

Tactical decision-making: Recent studies of the processes involved in decision-making at the individual and team levels have examined:

- the utility of "cross-training" on team performance in a naval threat assessment simulation
- how military and civilian personnel differ in their use of ambiguous information when making decisions
- how fatigue due to sleep loss affects decision-making performance at the individual and team level
- how loss of audio communication affects performance in distributed teams
- how differences in decision-making styles affect the way people gather and use information when making decisions

Current studies are examining the effect of time pressure and ambiguous information on team performance in an anti-air warfare task and the utility of various computer-based decision aids on command performance.

Sleep loss and fatigue countermeasure studies: The facility can be used to conduct research on performance degradation resulting from fatigue due to sleep loss. Subjects can perform continuous (e.g., several days) psychological tasks as well as tasks that simulate the position of an operations duty officer in a brigade command post. The facility can also be used to study the effects of fatigue countermeasures, such as stimulating agents (e.g., modafinil, amphetamine, caffeine) as well as various non-pharmaceutical interventions (e.g., naps, exercise, and reduced workloads).

Availability

The TDMC2 facility is available under memoranda of understanding to other government agencies or under contract to civilian and commercial organizations.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Aircraft Crewstation Demonstrator

The Aircraft Crewstation Demonstrator uses rapid prototyping technologies and human-in-the-loop simulation to facilitate human engineering studies in support of Canadian Forces aircraft systems procurement and modification.

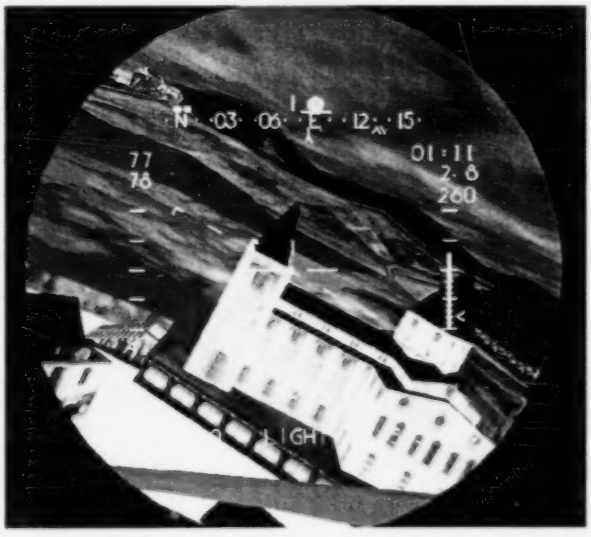
A customized software architecture permits the five ACD modules (aircraft model, virtual instruments, scene generation, simulation station, and manual controls) to communicate seamlessly and in real time.

Background

DRDC Toronto has developed, in conjunction with industry, a rapidly reconfigurable aircraft crewstation demonstrator (ACD) for use in human engineering studies in support of Canadian Forces (CF) operations. Current practice is to bring equipment into service and then determine its performance and "how to live with it." Now, instrumentation can be rapidly prototyped in the virtual world of the ACD, and human-in-the-loop studies may be performed on rotary and fixed-wing flight decks.

Facts and figures

Currently two ACDs exist, one at BAE Systems Canada Inc. (formerly Canadian Marconi Company Inc.) in Kanata and the other at DRDC Toronto. ACD components include dynamic models and virtual instrument panels for several CF aircraft (CH-146, CC-130, CC-144, CF-18, CT-142), generic manual flight controls, and out-the-window scene generation created from digital terrain elevation data and satellite imagery. An experimenter's workstation allows different scenarios to be designed, implemented,



The ACD simulates a variety of environmental conditions including scenery as viewed through night vision goggles.

Aircraft Crewstation Demonstrator

performed, and recorded. A new feature of the ACD is the Helmet Mounted Display option, giving pilots a 360° field-of-view of the virtual world.

Applications

Research: The ACD facilitates the assessment of crew performance under circumstances differing widely in task load and time pressure, environmental conditions, and simulated operations. The ACD's versatile components (e.g. terrain data bases, gaming environment, interactive scenario elements, wind conditions, time of day, fog, distributed simulation capability) make it ideal for studies in different military settings. The ACD's simulated night vision capability was exploited recently in a symbology study for the Griffon helicopter. Other human factors research performed in the ACD include issues related to crew resource management and interface compatibility.

Design: The ACD allows new interface designs to be implemented and evaluated in a simulated flight environment. Usability studies allow new interfaces or systems to be tested within the design cycle. This process enables the evaluation and integration of potential design modifications prior to procurement. A Direct Voice Input interface has been developed and tested, and is now integrated within the ACD.

Training: The ACD can be used as a part-task trainer, allowing certain aircraft subsystems to be learned in different flight environments.

Users

Defence R&D Canada and the Directorate of Technical Airworthiness are the prime users of the ACDs located at DRDC Toronto and BAE Systems Canada Inc. The ACDs are used for applied research, as well as test and evaluation activities. The University of Toronto is collaborating with DRDC Toronto to develop a course on Human Factors in Decision Making where four new devices, based on ACD technologies, will be an integral part of the curriculum.

Other: The components of the ACD, in principle, can be reconfigured for naval and land vehicles. As well, this technology may be extended to a variety of commercial and industrial applications.

The ACD has been used to conduct research in Direct Voice Input, Symbology, and Radar Warning technologies. Future work may include army and navy applications.

Availability

The ACD is available under memoranda of understanding to other government agencies or under contract to civilian and commercial organizations.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Human-Computer Interaction

Objective:

To enhance system effectiveness through research and development of theories, tools, techniques and data to facilitate Human-Computer Interaction.

Background

Human-Computer Interaction (HCI) is concerned with the principles for design and development of the human-computer interface. Much of the literature on HCI has been devoted to test and evaluation to identify the problems people have when using computer systems. The increasing importance of information in military operations requires a research program to support the specification, design, development, or selection of effective human-computer interfaces. The existing research program at DRDC Toronto provides a basis for HCI research in the areas of:

- translation of operator task analysis into an operator interface;
- use of colour in complex information displays;
- integration of difference sources of information;
- operator trust, performance, and workload when using automated aids; and
- effective use of audio displays, including 3-dimensional sound.

Electronic chart on a Maritime Coastal Patrol Vessel. Well-designed electronic charts can improve situation awareness in a wide range of naval tasks.

The current Ops room on the Canadian Patrol Frigate. Improved knowledge of HCI should lead to more effective presentation and processing of the large quantities of information that must be handled.

Organization

The work is conducted by the Human-Computer Interaction (HCI) Group. Some of the research is carried out in collaboration with defence scientists at DRDC Valcartier and DRDC Atlantic.

Human-Computer Interaction

Progress

Colour displays: Research in colour displays supports new international standards for electronic chart information display systems and specifications for displays for towed array sonar systems.

Operator-interface design: A hardware prototype of an improved interface for a multi-sensor detection and surveillance system (for search and rescue) is being developed.

3-Dimensional sound: An experimental program to investigate the potential of 3-dimensional auditory displays is underway.

Display symbology: A series of experiments is being conducted to investigate the principal parameters that affect symbol visibility on complex displays including task, set composition, and shape.

Future directions

Operator task analysis: Emerging theoretical approaches to defining the operator-machine interface will be explored.

Audio displays: Future research will lead to the development of specifications for the use of 3-dimensional auditory displays and improved specifications for auditory alerts.

Display technology: Research is underway, in collaboration with Computing Devices of Canada, to investigate the impact of display technology on processing of information in tactical displays.

Visibility of information on complex displays: Research is in progress to examine the factors affecting an operator's ability to attend to information on complex displays.

Visualization of large data sets: Research is planned to investigate the suitability of various methods of visualizing and navigating through large amounts of data as a function of task requirements.

Good HCI involves the effective integration of multiple sources of information and the effective utilization of all senses.

For more information

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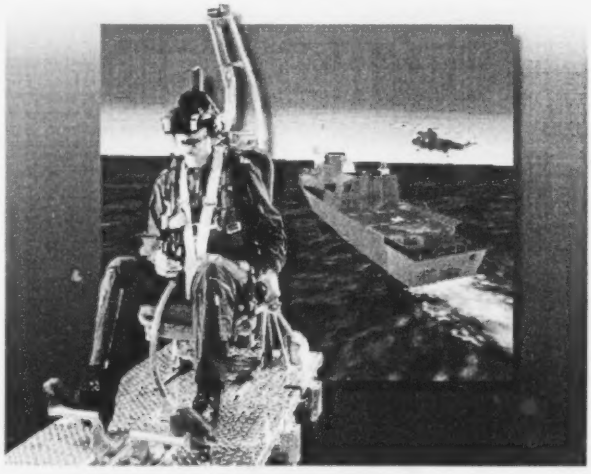
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Helicopter Deck-Landing Simulators

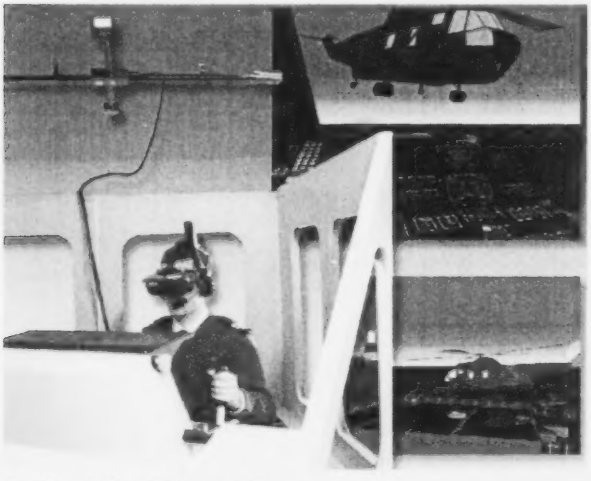
Objective:

To develop a low-cost simulator for training helicopter deck-landing skills to Canadian Forces pilots and aircrew.



Background

In response to a request from the operators of the Canadian Forces (CF) Sea King helicopter, DRDC Toronto has undertaken the research and development of a virtual reality (VR) simulator for training helicopter deck-landing skills. The task involves landing a Sea King aboard a Canadian Patrol Frigate – a skill traditionally acquired at sea, following individual training on a simulator that does not have a visual display. DRDC Toronto has previously exploited VR technologies and commercial off-the-shelf components to teach ship-handling skills to junior naval officers. The goal of the current project is to determine if these inexpensive technologies are effective in teaching complex and demanding tasks such as helicopter deck-landings.



Landing Safety Officer simulator.

Technical uncertainties about the use of these technologies were reduced by building a helicopter deck-landing simulator from VR and commercial components, and by assessing their value through "transfer-of-training" – how well skills acquired on one system are transferred to another.

The work also attempts to address yet-unsolved problems with helicopter simulator training by making use of head-mounted displays that can provide stereoscopic information to aid judgement of visual distance to nearby objects.

Progress

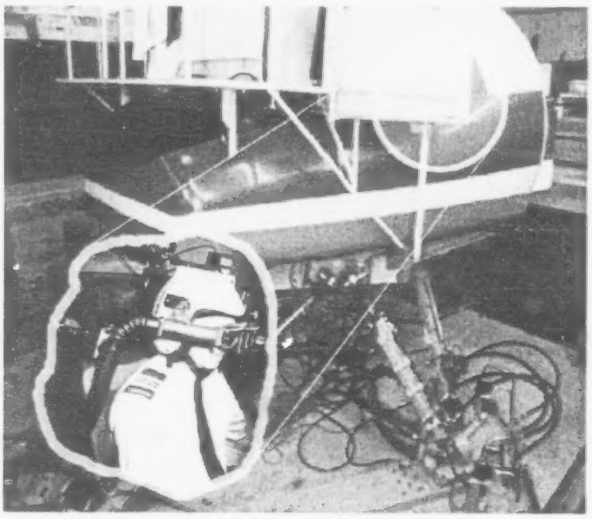
A traditional transfer-of-training study would involve testing at sea – an expensive, risky approach with little experimental control. Therefore, the experiment plan

Helicopter Deck-Landing Simulators

involved investigating transfer-of-training between two simulators – DRDC Toronto's VR simulator, and a "high-end" simulator using state-of-the-art (SOA) components.

The SOA simulator was developed under contract by the University of Toronto Institute for Aerospace Studies (UTIAS). Its principal components include a cockpit mounted on a conventional, six degree-of-freedom hydraulic motion base, hydraulic force loaders for the cyclic, a sophisticated image generator and a stereoscopic fibre-optic helmet-mounted display. The validity of this device was established first by qualified test pilots, and then by reverse transfer-of-training (i.e., by comparing how well Sea King pilots performed in the simulator in comparison to pilots without deck-landing experience).

The VR simulator built by DRDC Toronto substitutes low-cost, off-the-shelf components for each of the



The UTIAS simulator and fibre-optic helmet-mounted display.

expensive, special-purpose components of the SOA simulator. It consists of a Sea King seat and primary flight controls (rudder, cyclic, collective) mounted upon an electrically-driven, six degree-of-freedom motion base. Springs are used to centre the cyclic, and a low-cost, binocular head-mounted display is used to view the visual scene provided by a general-purpose image generator. The flight dynamics and other critical models, such as the ship's appearance and behaviour, are identical to the SOA simulator.

The effectiveness of DRDC Toronto's VR simulator was assessed in two phases. The subjects were 12 helicopter pilots without deck-landing experience. First, the pilots were required to make 40 deck-landings with the VR simulator. The same pilots then made another 40 landings with the SOA simulator. As in the reverse transfer-of-training study, the pilots showed improvement with practice. This group's learning curve appeared unbroken when they transferred to the SOA simulator and they showed superior performance on their first encounter with the SOA simulator.

The combined results of these two transfer-of-training studies suggest that the VR approach is a viable alternative to the SOA simulator for training deck-landing skills. This implies that the VR approach could provide the means for low-cost simulation of other demanding helicopter training tasks, such as hovering, hoisting, or autorotations, or for less demanding tasks where strong reliance on visual and motion cues are not as critical. The experimental version of the VR simulator is now being reengineered for training use at CFB Shearwater, Nova Scotia.

Future directions

Future work at DRDC Toronto will expand the simulations to include:

- other Sea King tasks such as assisted recoveries;
- the development of a federation of devices, including simulations for the Landing Signals Officer, Flight Deck Control Officer and Officer-of-the-Watch; and
- generalization of the concepts to other helicopters, including civilian helicopters.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Air Accident Investigation Support

Objective:

To provide expertise on the human factors and survivability aspects of air accidents in support of the Directorate of Flight Safety.

Background

Canadian Forces (CF) air operations encompass many challenging environments and missions. When accidents occur, the primary cause in the vast majority is human performance, or human interaction with systems. Directorate of Flight Safety (DFS) Flight Safety Investigations (FSI) have a clear requirement for access to expertise in human factors, as well as in the aircraft and its operations. DRDC Toronto supports DFS by providing a working group to conduct comprehensive human factors and life support equipment investigation and review of major air accidents. This team also provides on-site assistance to the FSI. The ultimate objective is to recommend remedial and proactive measures to enhance the safety of CF air operations.

Organization

The air accident support team consists of members of DRDC Toronto's Aerospace Life Support Section.

Air Accident Investigation Support

Depending on the nature of the accident, members may include a flight surgeon, a pilot on ground tour with human factors training, technicians with expertise in life support equipment, a biosciences officer, and a technical expert in Life Support Equipment (LSE).

Investigation support

On-site assistance: Some accident support team members are also called upon as on-site assistants to DFS FSIs. Launched in December 1994, this role has proven very effective in increasing the quality of human factors and survivability aspects of accident investigations.

Post-investigation reviews: The team attempts to determine relevant factors, interactions and conditions affecting performance from the supervisory, training and operational levels of the system. This group also evaluates life support equipment and survivability issues.

Investigation procedure: An investigation procedure has been developed to address the human factors and survivability elements of air accidents. This "checklist" protocol guides an investigator through the relevant human factors and life support equipment issues and provides a standard format for recording information during investigations.

For more information

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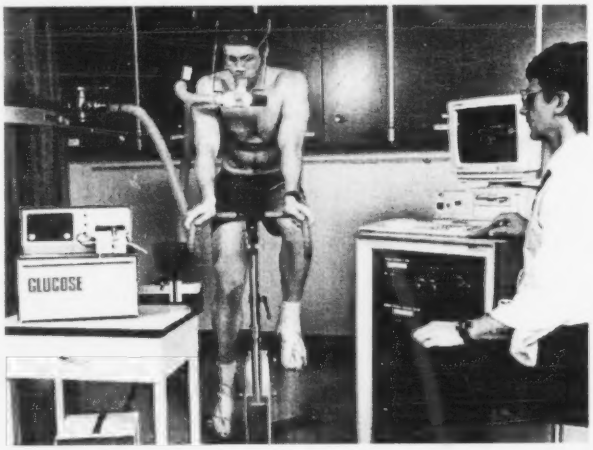
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Exercise Physiology

Objective:

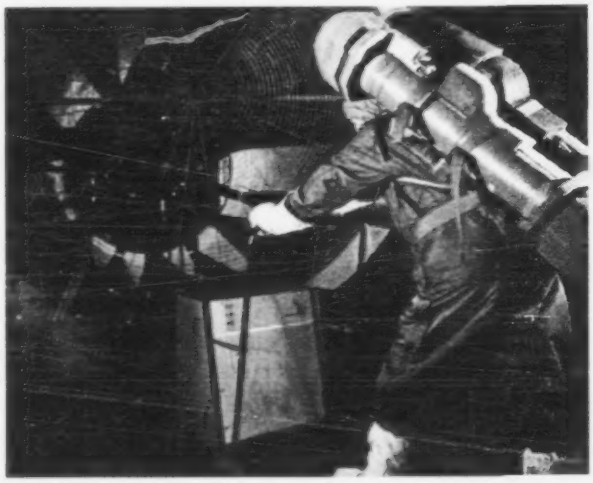
To enhance the operational effectiveness of Canadian Forces personnel by investigating human responses to exercise and by developing means of increasing physical work capacity.



Exercise tests using ergometers, metabolic carts and blood analysers are performed to assess physical work capacity.

Background

Military operational requirements can demand a broad range of intensities of physical exertion, from prolonged low intensity to short bursts of maximal effort. Work is performed in environmental conditions ranging from extreme cold to hot desert or tropical climates. Physical fitness and work capacity have a direct bearing on operational effectiveness. Research at DRDC Toronto focuses on identifying and understanding muscle fatigue and physiological factors that limit work tolerance, predicting the capacity to sustain work performance of various intensities, and developing strategies to acutely enhance physical performance and improve physical training methods. All of our laboratory techniques can be adapted for field use.



Physical work capacity can be determined in environmental extremes of temperature and wind, using DRDC Toronto's climatic chambers.

Organization and resources

The exercise physiology research program is conducted by members of the Human Performance and Protection Group using DRDC Toronto's exercise physiology laboratory and climatic facility. Equipment available to quantify work includes metabolic carts, computerized electromyographic (EMG) analyses, motorized treadmills and cycle ergometers. Automated analyzers are available for blood metabolites, blood

Exercise Physiology

gases and pH. Biochemical assays are performed using fluorimetry, spectrophotometry, high performance liquid chromatography and radioimmunoassays.

Research program

Ergogenic aids: Studies of the effects of nutritional and/or pharmacological treatments have shown that performance is significantly enhanced by the ingestion of creatine, modafinil or the combination of caffeine and ephedrine. Several studies with the latter combination of drugs have shown an advantage at all exercise intensities lasting from as short as 30 seconds to as long as 45 minutes.

Protective clothing and heat strain: Many studies have addressed the separate and interactive effects of heat acclimation, hydration and aerobic fitness on heat tolerance when nuclear, biological and chemical (NBC) protective clothing is worn in hot environments. The findings have revealed that hydration is the most easily manipulated and most important variable to influence tolerance time.

Exertional heat illness: During recruit basic training in particular, occasional cases of exertional heat illness still occur, despite the fact that current guidelines are in place to curtail activity when environmental temperatures exceed certain levels. Present research is addressing the impact of prior exercise on susceptibility to heat illness for inactive men and women.

Future directions

Ergogenic aids research will focus on finding alternatives to ephedrine and on the interaction of several nutritional supplements when taken in combination. The impact of modafinil on exertional heat illness will also be studied. Manipulations of heat storage capacity with fluid ingestion before and during heat stress will be examined as a means to enhance tolerance time when protective clothing is worn. In addition, the importance of aerobic fitness and body fatness will be addressed for conditions that involve wearing protective clothing.

Research has focussed on ways to reduce the heat strain associated with wearing NBC protective clothing in hot environments.

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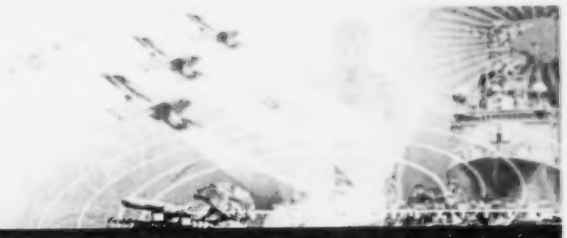


Defence R&D Canada – Toronto

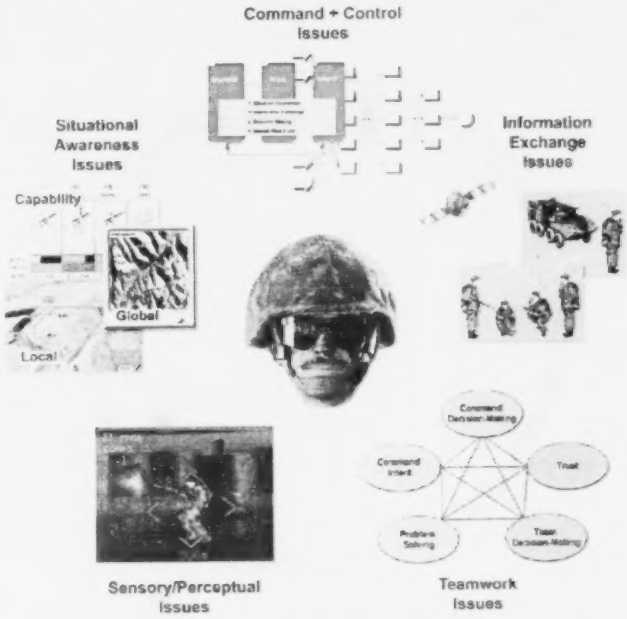
Soldier Information Requirements (SIREQ) Technology Demonstration Project

Objective:

To define and empirically validate the performance requirements for the future Soldier System by demonstrating capability enhancements in command execution, target acquisition and situational awareness for the individual Canadian dismounted soldier in 2010-2015.

Background

The Integrated Soldier System Platform (ISSP) capital acquisition project will acquire clothing and equipment to enhance Canadian soldier capabilities in the five NATO capability areas of Lethality, C^{4}I (Command, Control, Communications, Computers and Intelligence), Survivability, Sustainability and Mobility. Phase I of this project, the Soldier Information Requirements (SIREQ) Technology Demonstration (TD), is an R&D effort focussed on aspects that could provide revolutionary enhancement of capability – the target acquisition aspects of Lethality and the command execution and situational awareness aspects of C^{4}I. Through human factors research, SIREQ TD will determine the information requirements of the Canadian dismounted infantry soldier and will recommend the best means of presenting that information to enhance operational performance under the range of expected mission/task scenarios and conditions of use.

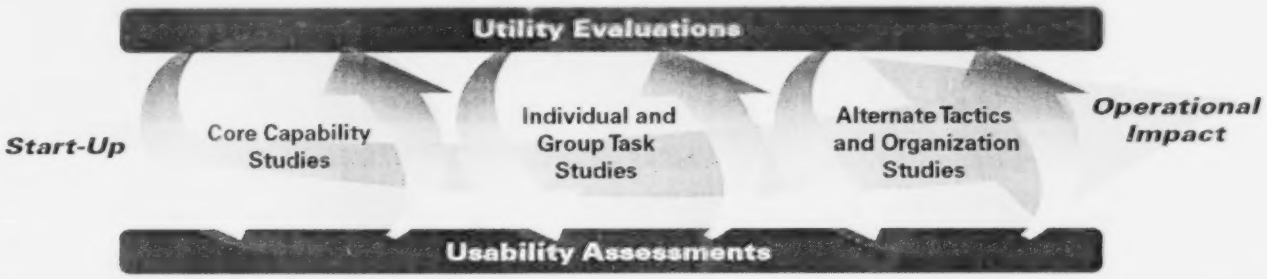


Soldier Information Requirements identified through Cognitive Task Analysis.

Organization

SIREQ TD is being conducted by Defence R&D Canada with the support of the Land Force. DRDC Toronto is the lead laboratory for the project, drawing upon multi-disciplinary expertise from other DRDC labs and government agencies, as well as industry, including: DRDC Valcartier; DRDC Ottawa; Communications Research Centre Canada; Directorate of Operations Research – Joint and Land; Oerlikon Aerospace Incorporated; and Human Systems Incorporated.

Soldier Information Requirements (SIREQ) Technology Demonstration Project



Phases of the SIREQ TD experimentation program.

Project description

SIREQ TD was approved for implementation on 30 March 2000 as a four year phased project comprising:

Preparation/Start-Up Phase – development of detailed experimentation plans, Human Factors measures, and the preparation, development, acquisition and/or modification of experimentation equipment, test beds, simulation and modeling tools.

Core Capability Studies – experiments to determine the utility, usability and operational impact of providing soldiers with the range of potential enhancements in sensor, information exchange and visualization capabilities.

Individual and Group Task Studies – experiments to determine the impact of enhanced information capabilities on the range of soldier and section-level tasks including siting, control of movement, orders, control of fire, and navigation.

Alternate Tactics and Organization Studies – studies to asses the additional opportunities afforded by changes to tactics and section organization.

Progress

Four soldier mission/task scenarios have been developed: Attack, Defend, Patrol and Operations Other Than War (OOTW). Cognitive task analyses have been completed at the rifleman and section commander levels. Virtual reality simulation facilities/tools have been acquired to emulate existing and future technology-enhanced capabilities. A comprehensive experimentation program has been developed and over 50 lab and field trials have been conducted to date.

Project deliverables

Deliverables of the SIREQ TD project include: validated performance-based specifications for the ISSP capital acquisition; information technology concepts and prototypes; interface design guidance; scientific reports; and substantiation for further R&D.

For more information

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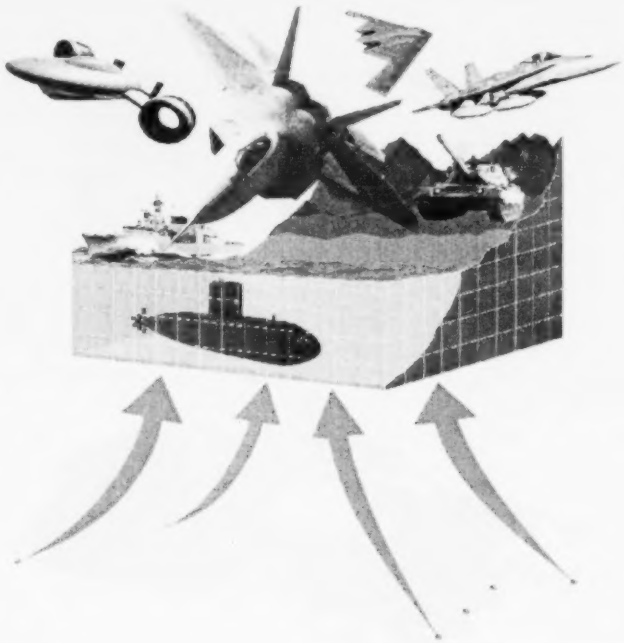
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Advanced Distributed Mission Training Technology Demonstration Project

Objective:

To provide the Canadian Forces with enhanced training capabilities via the development and optimized use of advanced simulation technologies.



The ADMT TD will be part of a future, synthetic environment that will permit all elements of the CF to exploit simulation and modelling for equipment acquisition, operational analysis, training, mission planning, and rehearsal. Live, virtual and constructive entities will be able to interact in real-time in a common synthetic environment, even when their controlling elements are physically separated by large distances.

Background

The Canadian Air Force (CAF) will be relying on greater use of simulators in the future and is embracing the concepts of Distributed Mission Training (DMT) within synthetic environments to achieve their training objectives, including interoperability with allies. Defence R&D Canada (DRDC) has initiated the Advanced Distributed Mission Training (ADMT) Technology Demonstration (TD) project to help the CAF achieve these goals. The TD will provide a CF-18 simulator, fully interoperable with the US, to address inter-simulator networking issues, visual display fidelity, the use of constructive agents for friendly and opposing forces and the right mix of simulator and in-flight training. Collaboration with the US is supported by a Technology Research and Development Program (TRDP) Project Arrangement that was signed in September 1999.

The prime objectives of the ADMT-TD project are to advance the development of flight simulator technologies and to investigate the use of flight simulators for training team, collective, joint and coalition tasks. The ADMT-TD project will support the CAF Advanced Distributed Combat Training System (ADCTS) project through an ongoing process of technology investigation and risk reduction activities. An additional objective is to promote greater use of simulation and modelling for all elements of the Canadian Forces in equipment acquisition, operational analysis, training, mission planning and rehearsal.

Technology approach

The technology of flight simulation devices is advancing rapidly. Therefore, the ADMT-TD project will adopt an open-architecture, modular approach. This will allow frequent technology updates and the integration of

Advanced Distributed Mission Training Technology Demonstration Project

products from different suppliers. DND will then be able to select the best available components.

The ADMT-TD project has identified three key technology areas for advanced development and testing. These are:

- Visual systems;
- Training effectiveness; and
- Intelligent agent software.

International relationship

The ADMT-TD project is being conducted in collaboration with the Human Effectiveness Directorate (HEA), Warfighter Training Research Division (WTRD) of the United States Air Force Research Laboratory (AFRL). Additional work is being carried out by Canadian and US contractors. The WTRD originated and continues to push the advancement of DMT technologies and concepts; the US is our closest ally and the recognized leader of future coalition operations. Simulator interoperability with the U.S. may be required to achieve future interoperability in the air. It may also be needed for mission rehearsal, a possible future requirement for military operations as countries attempt to avoid loss of life, loss of equipment and collateral damage.

Low-cost, effective simulators are an essential foundation for affordable DMT. The WTRD addressed this requirement by developing the Multi-Task Trainer (MTT), a modular, deployable training device that has been adapted to a variety of air platforms including the F-16, A-10 and C-130. The same design approach will be used for the ADMT-TD. This way, compatibility with the US is assured and attention can be focused on areas of technological uncertainty and weakness. This approach also permits mutual support in maintaining the systems beyond the technology demonstrations.

Partnership with the USAF is consistent with the plan to expand Canada U.S. cooperation by leveraging resources with our closest allies. Alliance with the WTRD builds upon an existing foundation of cooperation established by recent personnel exchanges and joint investigations by the WTRD and DRDC Toronto, one of five research centres within Defence R&D Canada. Further efforts are underway within The Technical Cooperation Panel's Human Performance Group (Training Technologies Panel) and the NATO Research and Technology Organization.

Industry collaborative opportunities

DRDC is looking for industrial partners in the ADMT-TD project. Opportunities exist to showcase and advance your products and technology by active participation in this technology demonstration.

For more information

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Project Director:
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Scientific Authority:
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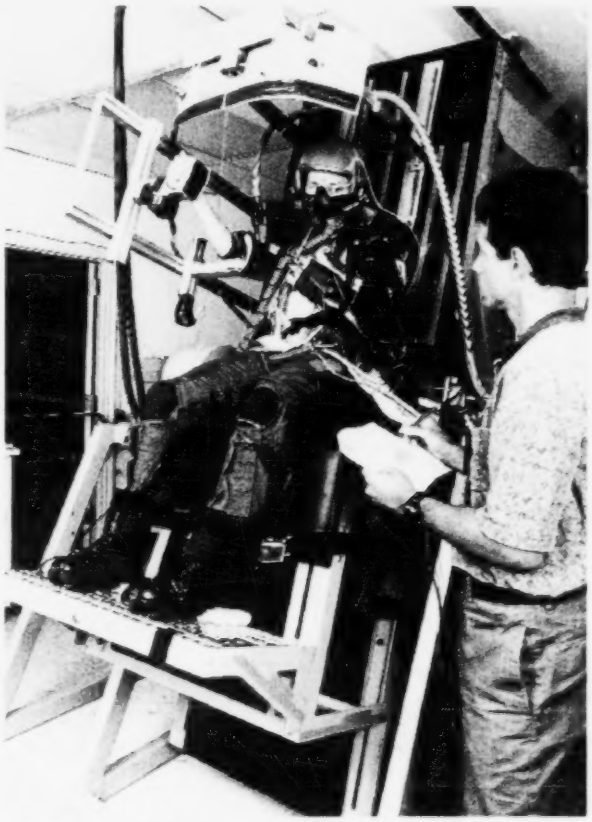
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Acceleration Physiology: G Transitions

Objective:

To study the underlying mechanisms in the human cardiovascular response to negative and positive gravitational forces (+/-Gz) using tilt bed simulations.



Here, the tilt bed is configured to simulate the cockpit environment.

Background

Aerial engagements in Canadian Forces (CF) aircraft such as the CF-18 expose aircrew to rapid transitions between positive and negative G forces (+/-Gz). Emerging research has shown that these +/-Gz transitions, although increasing the operational envelope of the aircraft, reduces aircrew tolerance to +Gz. This can increase the risk of visual disturbances and loss of consciousness.

DRDC Toronto research in this area uses a tilt bed to simulate +/-Gz forces. Results will lead to recommendations that enhance the safety and operational effectiveness of CF aircrew.

Organization

Tilt studies are conducted by the Aircrew Performance/Protection Group, part of DRDC Toronto's Aerospace Life Support Section. Medical support is provided by members of the Medical Assessment and Training Section.

Research capabilities

Tilt bed: The electronic computer-controlled tilt bed can tilt subjects to head-up or head-down orientations at rates of 5–45°/s. Subjects can be tilted either reclining or in the seated position, simulating the cockpit environment.

Instrumentation: Cardiovascular non-invasive instrumentation includes transcranial doppler, non-imaging portable nuclear angiography, impedance cardiography, and measures of continuous arterial blood pressure and peripheral blood flow/venous function.

Acceleration Physiology: G Transitions

The neck chamber device is used during experiments designed to modify cardiovascular reflexes during G-transitions.

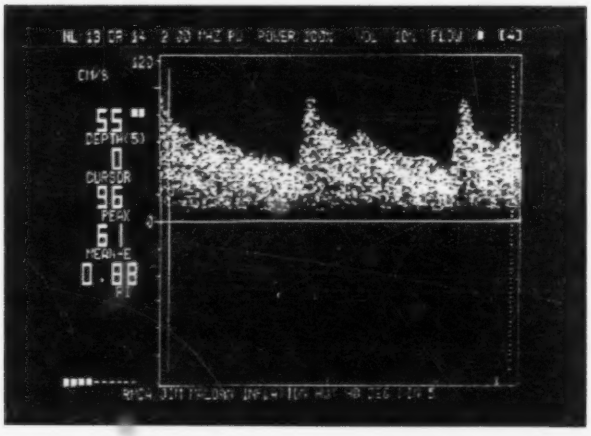
Experimental pressure techniques: A variable-pressure neck chamber system is used to modify carotid baroreceptor function, which evokes changes in both sympathetic vasomotor tone and physiological responses to +/-Gz. A removable Lower Body Negative Pressure (LBPN) Chamber is also available to modify cardiovascular function and/or increase cardiovascular stress during tilting.

Other programs: The in-flight and human centrifuge research programs work in tandem with tilt bed research.

Future directions

Applications to other programs: Results of this research will be used in the development of life support equipment and techniques for the CF-18 and next-generation tactical helicopters, as well as in the ongoing cardiovascular modelling and "Smart" regulator/garment programs.

Collaborative efforts: Support for nuclear cardiology studies is provided by St. Michael's Hospital in Toronto. Other collaborations include clinical orthostatic intolerance research at Mt Sinai Hospital and the Faculty of Medicine, University of Toronto. Academic links will continue with graduate programs at the University of Toronto and York University.



Beat-to-beat cerebral blood flow doppler waveform.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

CF-18 Acceleration Protection: The STING System

Objective:

To reduce the risk of G-induced loss of consciousness, or GLOC, and to enhance physical performance and situational awareness of Canadian Forces aircrew by improving acceleration tolerance up to +7.5 G.

Background

The **S**ustained **T**olerance of **IN**creased **G** (**STING**) system development project is a continuation of the leadership in advanced acceleration (G) protection historically maintained by Canada since the Second World War. Until recently, the anti-G suit used in the CF-18 represented 1950s technology, which was inadequate and less effective than newer systems being introduced in modern high-performance aircraft worldwide. The STING system improves G protection and enhances the capability of CF-18 aircrew. It can be used in training aircraft as well as fighters. A commercial license has been issued for marketing STING internationally.

Technology

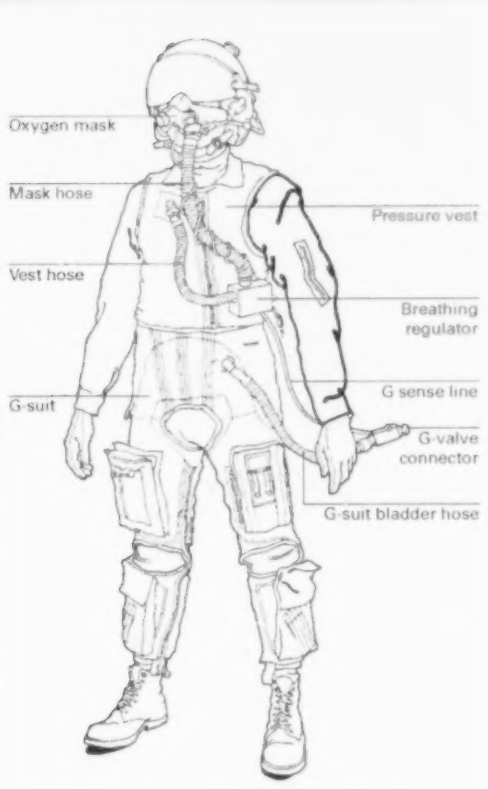
STING introduces a new anti-G suit with extended coverage and much larger leg bladders, doubling the protection of the traditional anti-G suit. Additionally, the STING system offers Pressure Breathing for G (PBG), accomplished through a new breathing regulator, a new pressure vest, a modified helmet configuration and a new oxygen mask. PBG increases protection even more dramatically by overcoming blood-flow limitations associated with the lower-body anti-G suit alone. The overall result is a system that allows sustained G-tolerance at levels up to +7.5 G with minimal or no straining, thereby reducing fatigue and enabling aircrew to focus on flying and mission-related activities.

Status

The STING anti-G suit and the complete system were tested in the centrifuge in 1994 and flight test

CF-18 Acceleration Protection: The STING System

evaluations began in 1995. The anti-G suit was introduced into service use in June 1998. The flight trials resulted in recommendations that have led to design and safety improvements, particularly integration of the multi-functional upper garment. Two more series of flight tests are planned – one to establish airworthiness of the full STING system with PBG, the other to evaluate its merits operationally.



How the system works

This STING system includes a trouser-like G-suit and a pressure vest. When the aircraft G-valve detects rising G levels, it automatically inflates the G-suit bladder and also delivers the pressure to the breathing regulator through the G sense line. The regulator then sends air at a lower pressure to the oxygen mask and vest (a method called "positive pressure breathing"), adding to the G protection.

Future directions

Protection from and capability with STING will be improved during the Advanced Aircrew Anti-G Systems Project. New data from this project, as well as data obtained previously in 40 sorties during the In-flight Research (IFR) Program, will be used as a basis for programming a new electronic, microprocessor-controlled anti-G valve. The combined STING and anti-G valve systems will provide optimal protection against all G threats, including the "push-pull" effect involving acceleration transitions between relative positive and negative G levels. A demonstration prototype is expected to be completed in 2004.

For more information

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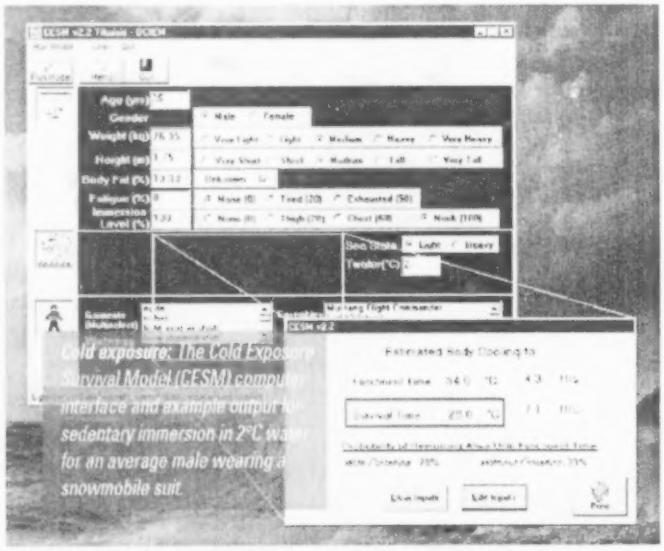
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Predictive Modelling

Objective:

To improve the safety and performance of Canadian Forces personnel in physiologically stressful environments through a predictive modelling capability.


Cold exposure: The Cold Exposure
Survival Model (CESM) computer
interface and example output for
sedentary immersion in 2°C wa
for an average male wearing a
snowmobile suit.

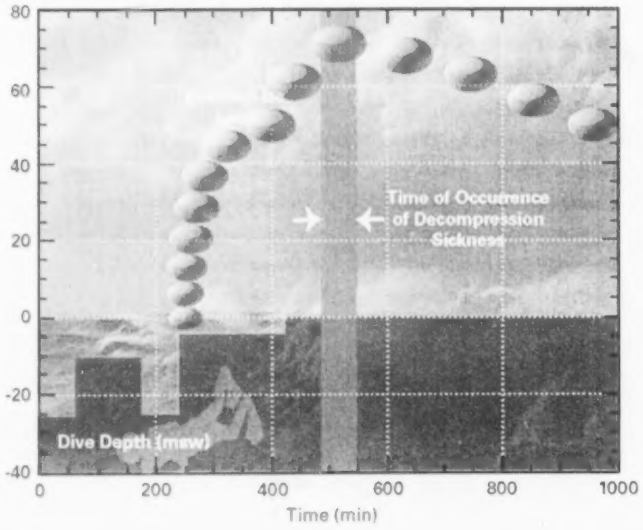
Background

Canadian Forces personnel frequently operate in adverse environments that can be life-threatening to the unprepared individual and can impose an impediment to maximum performance. Prediction of human response in such environments is essential to both operational and contingency planning. Mathematical modelling provides a concise and cost-effective means to obtain such predictions. Modelling also enhances scientific understanding and provides a technical platform for rapid evaluation of various untested scenarios. At DRDC Toronto, modelling expertise has been developed for three specific environments:

- cold exposure (thermal);
- diving (hyperbaric); and
- airborne contamination (respiratory).

Organization

Research in predictive modelling is conducted by members of DRDC Toronto's Human Protection and Performance Group.



Diving: *Correlation between the predicted bubble size using DRDC Toronto's Bubble Evolution Model with the range of occurrence of decompression sickness in three divers, for a repetitive dive to 25 metres of seawater (msw).*

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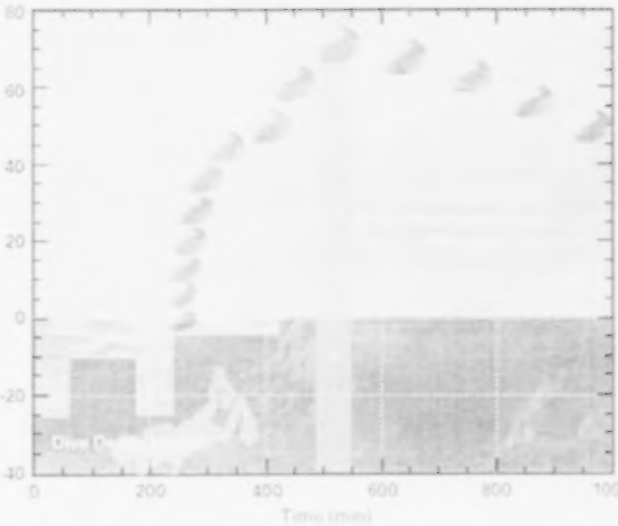

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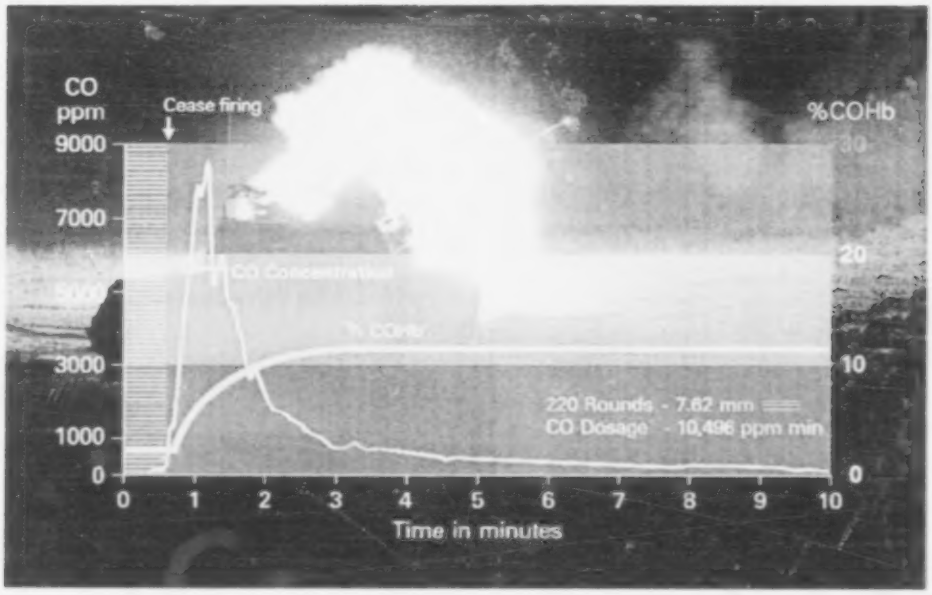

Airborne contamination: *Predicted percentage of blood carboxyhemoglobin (COHb) for an exposure to carbon monoxide (CO) due to live firing during heavy work in a Leopard tank. Green, yellow and red zones correspond to safe, hazardous and potentially lethal levels of %COHb.*

Progress

Cold exposure: The Cold Exposure Survival Model (CESM) was developed primarily as a decision aid for Search and Rescue, but is also applicable for the evaluation of clothing protection under extreme environmental conditions and as an educational or training tool for cold survival. Its predictions apply for exposure on land, immersion in water, or a combination of the two.

Diving: The Bubble Evolution Model was developed to help assess the risk of decompression sickness (DCS) in diving. By using dive depth and duration to predict the maximum size of the bubbles that cause DCS, the model can help determine when divers are at greatest risk.

Airborne contamination: The COHb (carboxyhemoglobin) Prediction Model was developed to forecast the risk of carbon monoxide (CO) toxicity in hazardous environmental atmospheres (e.g., from the discharge of weapons firing).

Future directions

Cold exposure: Modifications to the CESM will include predictions of limb cooling and times to motor and cognitive performance degradation.

Diving: The Bubble Evolution Model will be expanded and validated. This work will support the development of decompression algorithms for military diving.

New initiatives: To develop reliable models of the delivery and depletion of liposome-encapsulated drugs, and models to predict the decrements in performance of dismounted soldiers due to various debilitating factors such as thermal stress and fatigue.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

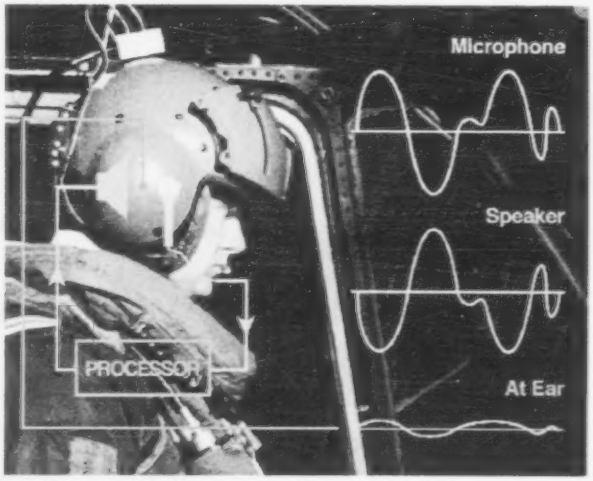
Active Noise Reduction Technology

Objective:

To promote hearing conservation and communications effectiveness in the Canadian Forces through research into analog and digital active noise reduction technology for headsets.

Background

Canadian Forces (CF) personnel in operational environments are frequently exposed to noise levels that can interfere with communications and potentially damage hearing. Active noise reduction (ANR) reduces noise exposure through the action of interfering sound waves. Noise within the ear shell of a headset or helmet is processed electronically and reintroduced out of phase, causing a net reduction of noise at the ear. ANR research at DRDC Toronto provides a Canadian testing and resource centre in which developments in ANR technology can be monitored and promoted.



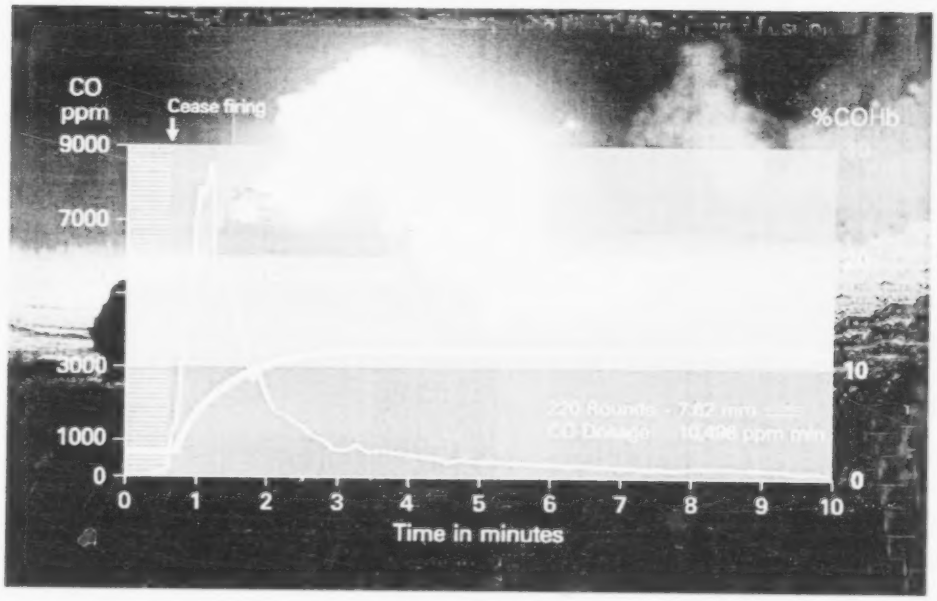
Components and waveforms of an analog helmet ANR system.

Components of a digital ANR system.

Analog ANR headsets can reduce noise exposure and improve communications in aircraft and mobile equipment. However, they require careful fitting and can overload or become unstable when the seal around the ear is broken. The noise reduction performance of analog "feedback" systems is limited by the need to maintain a stability margin during operation. Thus, analog ANR is not easily optimized for use in different noise fields.

Digital ANR headsets with signal processing capability have demonstrated the potential to overcome these problem areas. Using "feedforward" architecture, digital ANR adapts to an intrusive noise field by designing, implementing and monitoring its own filter, establishing an optimal listening environment for the

Predictive Modelling



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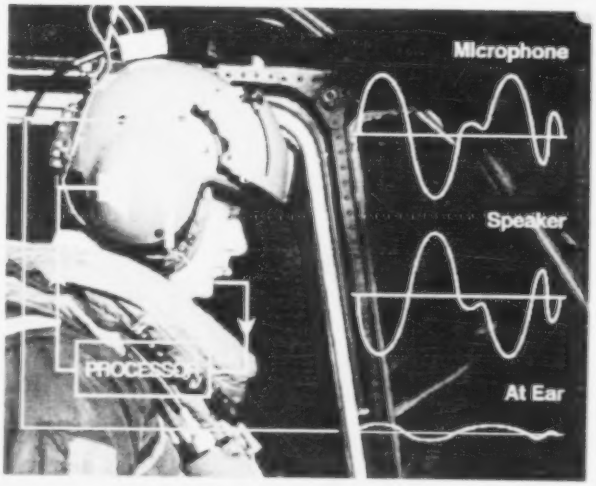

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Active Noise Reduction Technology

user. Thus, for example, application in helicopters and vehicles would result in similar at-the-ear noise levels. Digital ANR headsets are inherently less dependent on a good seal against the head.

Research capabilities

Laboratory facilities: DRDC Toronto's Noise Simulation and Modelling Facility is used to reproduce the noise of transportation equipment and model at-ear sound levels. ANR products can be studied in prospective environments, encouraging improvements in product design. Performance metrics include objective and subjective measures of noise attenuation, speech discrimination and signal detection, overload thresholds, ear seal integrity, transducer sensitivity, and frequency response. The synergistic effect of ANR and 3-dimensional audio communications can also be studied in the laboratory.

Field trials: When required, on-site studies are conducted to collect data on noise attenuation, speech discrimination and noise exposure due to intercom traffic.

International affiliation: ANR performance guidelines have been drafted and an ASCC Advisory Publication on testing methods distributed internationally. In addition, a consortium of international researchers studying ANR preformance metrics for military environments has been formally recognized as a NATO RTO Task Group.

Digital ANR adapts to an intrusive noise field using a "feed-forward" system.

Future directions

Equipment evaluations: New ANR systems and technology will be evaluated for effectiveness in high-noise environments.

Collaborative activities: Further applications of digital signal processing to ANR are planned in collaboration with the National Research Council (NRC). The goal is to create the "best listening" condition for the user regardless of the environment, and to reduce dependence on fitting around the ear.

Business opportunity

R&D has resulted in the fabrication of a compact and portable technology demonstrator to study digital ANR capabilities. Potential areas for civilian and military applications include helicopters, propeller-driven aircraft, heavy vehicles, tracked vehicles, road-building or forestry vehicles and railway locomotives. Further applications exist in the machinery spaces of ships, in engine test cells, in mining/geological operations and in electric power generating stations. The next phase involves sharing this patented technology under license with interested industrial partners who visualize an opportunity for final development and commercial exploitation.

Organization and resources

The hearing conservation research program is carried out by the Communications Group, DRDC Toronto's Noise Simulation Facility is used to conduct physical evaluations (*see Fact Sheet F-08*).

For more information

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Active Noise Reduction Technology

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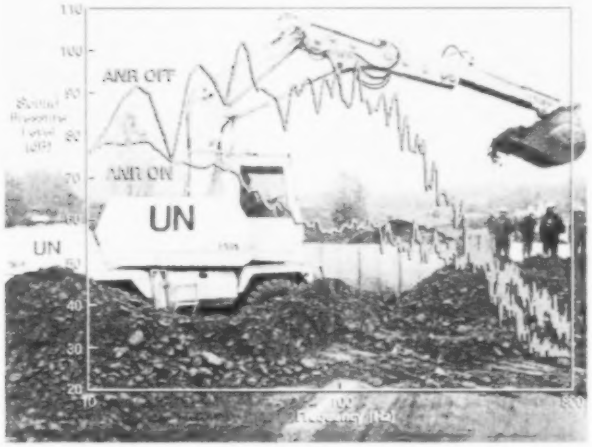

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Noise Exposure and Hearing Conservation

Objective:

To provide a central resource for research in noise exposure and hearing conservation issues for application in Canadian Forces training and operational environments.

Background

Canadian Forces (CF) personnel, especially those in artillery, infantry, armour and related trades, can sustain hearing loss as a result of occupational noise exposure that is costly in both human and financial terms. DRDC Toronto is frequently asked to advise CF directorates and project managers on the noise hazard associated with the operation of military equipment, and the degree of hearing protection required to eliminate the hazard. As an advisor to the Surgeon General and the Directorate of Medical Policy, DRDC Toronto studies and implements ways of reducing exposure to noise while maintaining operational effectiveness. Working closely with field units, we are involved in many aspects of noise measurement and analysis, noise control, communications and psychoacoustics.

An in-flight assessment of noise levels in the CC-130 Hercules.

Organization and resources

The hearing conservation research program is carried out by the Communications Group. DRDC Toronto's Noise Simulation Facility is used to conduct physical evaluations (*see Fact Sheet F-08*).

Noise exposure database

DRDC Toronto has developed a noise and hearing protection database for easy access to information on noise from a broad range of CF equipment. The

Noise Exposure and Hearing Conservation

database includes attenuation (noise reduction) profiles of all protective devices available in the CF supply system. It contains attenuation spectra for 30 different protectors and over 800 entries of noise data recorded by our staff as far back as 1950. Each entry includes octave-band and overall sound levels as well as source information. All noise information is categorized as either land, sea or air. Sub-categories are also used; for example, naval noise sources are grouped by vessel name or class, compartment, and propulsion system. Protector data can be retrieved using the military designator, device name, or type (e.g., earplug or helmet). At-ear noise estimates are given in octave-band spectra and "A-weighted" sound levels. Estimates of acceptable exposure time, according to Canada Labour Code regulations, can be made for any combination of equipment and hearing protector and if necessary, to establish operational constraints.

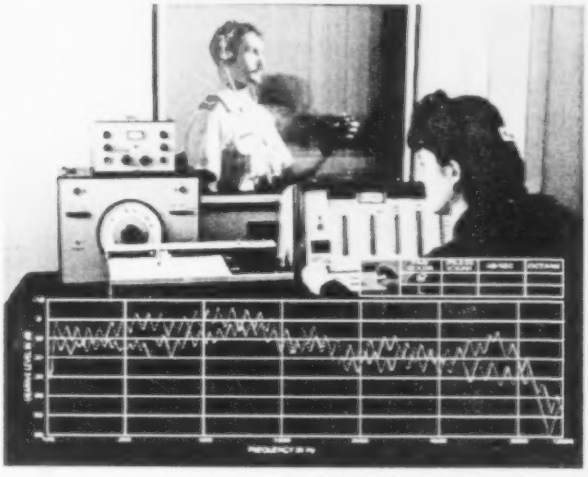
Research capabilities

Noise measurement: Acoustical working environments can be measured using state-of-the-art equipment to conduct site surveys and assess human exposure. For example, miniature microphones can be placed inside headsets to assess the at-ear sound levels of radio and communications traffic. Data are gathered and analyzed using techniques that are matched to requirements. In armoured vehicles, for instance, noise dosimetry is used to account for time-varying sound levels that result from changing operating conditions. Applications range from the assessment of howitzer noise for avalanche control crews, to the noise exposure sustained by CF bandsmen.

Assessment of hearing protection devices: Headsets and helmets are evaluated in our test facilities by comparing at-ear sound levels with and without protection. If noise levels are considered dangerous, manikins fitted with artificial ears are used rather than human subjects.

Communication in noise: Several standard speech-discrimination-in-noise tasks have been computerized, making experiments easier to conduct. The most recent of these is the Modified Rhyme Test, combined with the Maximum Likelihood Procedure, for rapid investigation of the relationship between speech-to-noise ratio and intelligibility in military systems. During in-flight investigations, speech material is pre-recorded to minimize the involvement of flight personnel.

Audiometry: DRDC Toronto conducts audiometry (hearing tests) for pilot screening, helmet fitting and CF medical referrals. Audiometry provides a reliable tool for detecting the onset of hearing impairment and allows the effects of hearing conservation efforts to be monitored.



A hearing test in progress and the resultant audiogram.

For more information

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Database Manager
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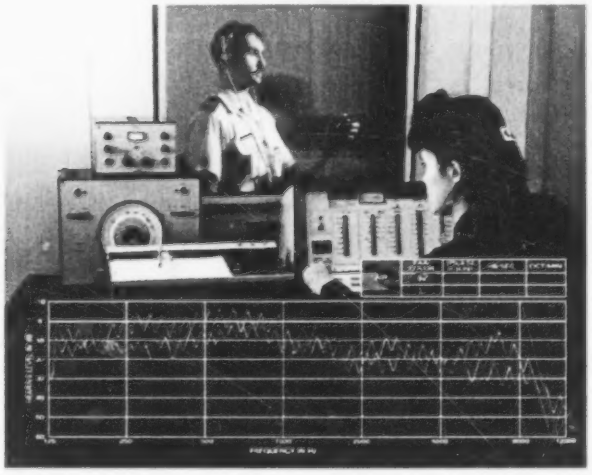
Research capabilities

Noise measurement: Acoustical working environments can be measured using state-of-the-art equipment to conduct site surveys and assess human exposure. For example, miniature microphones can be placed inside headsets to assess the at-ear sound levels of radio and communications traffic. Data are gathered and analyzed using techniques that are matched to requirements. In armoured vehicles, for instance, noise dosimetry is used to account for time-varying sound levels that result from changing operating conditions. Applications range from the assessment of howitzer noise for avalanche control crews, to the noise exposure sustained by CF bandsmen.

Assessment of hearing protection devices: Headsets and helmets are evaluated in our test facilities by comparing at-ear sound levels with and without protection. If noise levels are considered dangerous, manikins fitted with artificial ears are used rather than human subjects.

Communication in noise: Several standard speech-discrimination-in-noise tasks have been computerized, making experiments easier to conduct. The most recent of these is the Modified Rhyme Test, combined with the Maximum Likelihood Procedure, for rapid investigation of the relationship between speech-to-noise ratio and intelligibility in military systems. During in-flight investigations, speech material is pre-recorded to minimize the involvement of flight personnel.

Audiometry: DRDC Toronto conducts audiometry (hearing tests) for pilot screening, helmet fitting and CF medical referrals. Audiometry provides a reliable tool for detecting the onset of hearing impairment and allows the effects of hearing conservation efforts to be monitored.



A hearing test in progress and the resultant audiogram.

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Soldier Load Carriage Systems: Biomechanical Measurement Tools

Objective:

To develop standardized tools, models and techniques for the design and objective assessment of soldier load carriage systems.

Background

Canadian Forces (CF) soldiers are often required to carry heavy loads (sustainment and fighting supplies) for long durations and distances, and must be fit to perform once they reach their destination. Effective Load Carriage Systems (LCSs) – such as webbing, load-bearing vests, patrol packs and rucksacks – are critical to soldier safety, mobility performance, and ultimate operational effectiveness. DRDC Toronto's Operational Human Engineering Group supports the development and testing of advanced LCSs through in-house and contracted work. The aims of this work are:

- To better understand soldier load carriage capabilities and requirements;
- To develop tools, models and techniques that permit rapid objective assessment of LCSs and their components; and
- To support the rapid, iterative development and testing of advanced fully-integrated LCS for the Clothe the Soldier and other soldier system projects (Canadian and allied).

Technology status

The LCS assessment and modelling tools were developed under contract by the Clinical Mechanics and Ergonomics Research Groups at Queen's University, Kingston, Ontario. Intellectual property rights are held by the Crown. The technology has been licensed to Queen's University and is available to allied militaries and industry in support of their LCS development and research programs.

Prototype Clothe the Soldier Load Carriage System being tested on the Dynamic Load Carriage Simulator.

Soldier Load Carriage Systems: Biomechanical Measurement Tools

Progress

The following components of the R&D program have been completed:

- In-depth analyses of the factors affecting human load carriage performance and soldier load carriage equipment needs
- Development and validation of a suite of objective biomechanical LCS assessment tools and techniques
- Objective evaluation of state-of-the-art commercial and military LCSs
- Development of recommended performance-based tolerance limits and design guidelines
- Development of a 2D static biomechanical model to assist with the prediction of forces, moments and pressures imposed upon the body by various LCS designs
- Application to the iterative development and testing of the new Clothe the Soldier load carriage system, soon to be in phased procurement for the CF

The following tools and techniques are available:

Dynamic Load Carriage Simulator: Used to evaluate the impact of different LCS designs on human comfort and performance. A computer-controlled pneumatic system moves a simulated human torso through typical walk, jog, run, slip and duck movements. The simulator measures LCS strap forces (using custom in-line strap load cells), peak and average skin pressures (using Tekscan™ pressure sensors), relative motion between pack/payload and body (using Fastrak™ sensors), and forces and moments on the spine (using a 6 degree of freedom load cell).

Dynamic Load Carriage Compliance Tester: Measures the natural stiffness of a pack suspension system as well as the resistance to trunk flexion, lateral bending and torsion motions of any torso clothing configuration (e.g., fragmentation protective vest).

Load Distribution Mannequin: Used to determine the range of load transfer options an LCS can provide as well as the load distribution effects of novel LCS strap configurations or suspension system components.

Other tools and techniques include:

- A standardized mobility circuit for human testing of LCS
- 2D static biomechanical load carriage model for predicting LCS performance
- A Calibration Jig for Tekscan™ Skin Pressure Sensors
- Custom In-Line Strap Load Cells for determination of strap forces
- A Trifilar Pendulum for determination of a LCS centre of mass and moment of inertia about all 3 axes
- A Prototype Portable Measurement System to permit in situ objective LCS measurement in field-based trials with human subjects

Future directions

A Dynamic Biomechanical Model (DBM) to improve prediction of LCS characteristics and their impact on human comfort and performance is under development. Work will commence to determine tolerance limit values for the pressures and forces associated with carrying loads. Results of these efforts will be applied to improve international standards for military LCS design and testing.

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DEFENCE R&D DEFENSE

Defence R&D Canada – Toronto

Mine Countermeasures Diving Systems

Objective:

To develop and improve mine-countermeasures (MCM) diving systems to protect Canadian and allied ships and waterways against sea mines.

Background

The Canadian Forces Experimental Diving Unit (EDU), located at DRDC Toronto, has been involved in the development of mine-countermeasures (MCM) diving equipment since 1978. The project, which began with a requirement to replace the in-service MCM diving set, has progressed to the development of systems that enhance the operational efficiency and safety of MCM diving.

Organization and resources

The EDU develops MCM diving equipment and procedures using DRDC Toronto's world-class hyperbaric facilities. EDU's staff are recognized leaders in this area and represent Canada on the ABCANZ-3 Information Exchange Program, NATO Underwater Diver Working Party and lead The Technical Co-operation Program's Mine Countermeasures Diving Specialists.

Progress

MCM equipment: Developed and introduced the Canadian Clearance Diving Apparatus (CCDA), a breathing apparatus capable of supporting a self-contained MCM diver to depths up to 54 metres and the Canadian Underwater Mine-countermeasures Apparatus (CUMA), a more advanced apparatus capable of MCM diving to 81 metres. Developed a major upgrade to both apparatus making them lighter and smaller with optimized control interfaces.

Decompression Tables: The CUMA provides a unique helium/oxygen gas mixture that requires customized

Mine Countermeasures Diving Systems

decompression tables. These were developed from the DCIEM helium/oxygen decompression model and validated by EDU. Experimentation further reduced the safe inter-dive interval from 18 hours to 6 hours and provided adjustments to the tables to permit repetitive dives after only 3 hours.

Marketing: Award winning transfer of technology to a Canadian civilian firm for manufacturing. Encouraged sales to foreign navies of CCDA, CUMA and their derivatives. Many navies adopted or evaluated these apparatus and decompression tables because of the world-leading technology.

Future directions

Short-term: Introduction of diver heating system, first version of diver tracking system, new equipment and procedures to extend emergency life support capacity and non- magnetic underwater lights

Long-term: Advancement of tracking, navigation, tactical, sonar, communications and information display technologies. Integration with other selected auxiliary equipment into procedures that optimize the use of divers in an MCM operation

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Diving Tables and Manuals

Objective:

To improve the efficiency and safety of Canadian Forces diving by the development of safe diving procedures and decompression tables.

Background

The Canadian Forces Experimental Diving Unit (EDU), based at DRDC Toronto, has conducted decompression research and development for over 30 years. Pioneering work in the use of digital decompression computers and years of research led to the development of the world-renowned DCIEM Diving Tables and Diving Manuals, as well as a computer database containing information on thousands of dives. In April 2002, DCIEM changed its name to Defence R&D Canada – Toronto. However, due to the close association of the name DCIEM with diving tables and manuals, these products will continue to be marketed under this trademarked name.

Organization and resources

Diving table development is carried out by members of DRDC Toronto's Experimental Diving Unit (EDU). Our world-class hyperbaric facility is used in the development of equipment and procedures.

Accomplishments

Air Decompression Tables: Developed in the 1980s for Canadian Forces (CF) operational use, these tables have also been adopted by foreign navies, commercial diving companies, and other civilian organizations.

DCIEM Sport Diving Tables: These decompression tables, adapted for use by recreational divers, have had wide acceptance by the sport diving community. They have been adopted or endorsed by several training agencies.

Helium-Oxygen Decompression Tables: These tables were developed 1986-91 to replace the US Navy partial pressure tables for operational mixed gas diving to 100 metres (330 feet).

CUMA Rebreather: Partial pressure oxygen tables for surface decompression have been completed giving divers procedures for diving to 81 metres and conducting repetitive dives in as few as three hours.

Doppler Monitoring: DRDC Toronto was the first research facility to use Doppler ultrasonics for monitoring bubbles in divers after decompression in the development of diving tables. Because of this work, nations around the world have begun using Doppler Technology to detect evidence of decompression stress.

Diving Tables and Manuals

Future directions

Research and development will be conducted in repetitive dive tables for MCM divers, and in probabilistic models of decompression for HeO2 diving (both constant fraction oxygen and partial pressure of oxygen modes). The probabilistic method offers great operational flexibility, and the ability for the operational commander to select the level of acceptable risk.

Commercial availability of products

As DRDC Toronto is a federal government research institute, we do not handle the sale or distribution of diving tables or any related products. The DCIEM Sport Diving Tables and Diving Manuals are produced commercially by Universal Dive Techtronics, Inc., and distributed by Bonica Precision Inc. All inquiries regarding product pricing or availability should be directed to Bonica Precision.

In Canada:

Bonica Precision Inc.
#1110 – 12171 Horseshoe Way
Richmond, B.C. V7A 4Z6
www.bonicadive.com/webpages/home.html

In the U.S.:

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Footwear Comfort Research

Objective:

To study the elements of comfort/discomfort of military footwear systems in an effort to improve comfort and reduce overuse injuries in Canadian Forces personnel.

Background

Footwear significantly influences the frequency of overuse injuries, the energy expenditure during a given task and the comfort level of the users. With respect to the comfort of footwear, the term "uniform" can be the cause of much discomfort. An army of uniquely-shaped individuals cannot be issued the same style of boot and ail, or even most, be expected to find it comfortable. Because military personnel are told to wear a particular type of footwear for a particular deployment, some missions may potentially be jeopardised because of foot injuries related to uncomfortable or improperly fitted footwear. The word "comfort" as it applies to footwear is a very nebulous term, and for many years research has been conducted to develop comfortable footwear without clearly defining the term. More comfortable footwear systems are a current requirement of Clothe the Soldier (CTS), a large army clothing and equipment acquisition project. DRDC Toronto is the scientific authority for this project.

Organization

Footwear comfort studies are carried out by members of the Operational Human Engineering Group.

Recent progress

Several studies are currently ongoing to attempt to define comfortable footwear.

Computer analysis of user input: Canadian Forces (CF) personnel are providing military footwear comfort data via a computer interactive procedure employing the "Repgrid" technique. The Repgrid is a reliable method of quantifying and statistically analysing relationships between core concepts of individuals about a cognitive dimension, like comfort.

Boot inserts: The University of Calgary (under contract) is performing a study to determine anthropometric and sensory factors (two core concepts of comfort) which may predict the short-term reaction of the foot to a set of selected boot insert constructions. Since boot style is mandated, the insert is the focus of providing better footwear comfort to the soldier.

Field trials: Military footwear performance specifications are being developed using the results of

Footwear Comfort Research

field trials in which carefully chosen test boots were worn by infantry soldiers. CTS is the driving force behind this effort.

Future directions

Sizing system evaluation: The CTS Wet Weather Boot currently being issued uses a sizing system recommended in part by the study mentioned above. The success of this sizing system will soon be evaluated.

Hot weather comfort: Hot weather comfort criteria will be developed for the CTS Temperate Combat Boot.

Recommendations for inserts: The most recent University of Calgary contract report proposed a classification or grouping of individuals based on foot characteristics. The report suggested, for each group, an insert type that would provide better comfort. The next step will be to develop a simpler method of determining to which group an individual belongs.

Prototype inserts for CF boots.

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Thermal Manikin Head

The Thermal Manikin Head is a computer-controlled, multi-zone device used to assess the thermal insulation of headwear.

Background

Outdoor activities in the Canadian winter require effective protection against heat loss from the head. The Thermal Manikin Head (TMH) was developed to facilitate basic and applied research in environmental physics, and to quantify the insulation value of headgear, including equipment used by the Canadian Forces (CF).

While other devices can only measure the heat lost from the entire head, the TMH can break the total down into the heat lost from four separate zones. This makes it a more sensitive tool for assessing the effects of headgear design on thermal insulation.

Technology

The TMH has four measurement zones: face, crown, back of the head and a narrow zone where the head band of a helmet or hat would be in contact with the head.

Each zone is covered with two circuits of fine wire embedded in layers of aluminum and epoxy. One circuit, of constantan wire, acts as a heater. The other circuit, made of copper, acts as a surface temperature sensor.

A computer adjusts the electrical power to the heater wires to so that the surface temperature of each zone is 10°C above the room temperature. The heat lost from each zone is equal to the electrical power required to maintain the temperature difference.

When used in DRDC Toronto's Climatic Chambers (in still air or in simulated winds of up to 35 km/h), repeated measurements of thermal resistance are within 2% of the mean value.

Applications

Basic research: An investigation of heat transfer from the face in wind found that that the classic wind chill index overestimates heat loss by a factor of about three, and that wind chill equivalent temperatures are up to 20°C too cold in extreme conditions.

Thermal resistance testing: The TMH can be used to measure the insulation value of virtually any headgear. It was used to rank candidate infantry helmets for the CF on the basis of thermal resistance.

Product improvement: The TMH has been used to assess the thermal effects of design changes on the flow of ventilating air in helmets, and in the

Thermal Manikin Head

development of a forced air rewarming system for victims of hypothermia.

Availability

DRDC Toronto's Thermal Manikin Head and Climatic Chambers are available under memoranda of understanding to other government agencies or under contract to civilian and commercial organizations.

The Thermal Manikin Head.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Dismounted Soldier Simulator

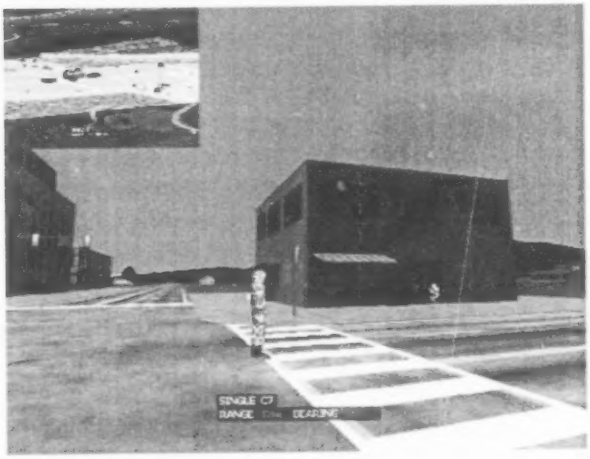
Objective:

To provide a synthetic environment for examining the utility, usability, and operational impact of future infantry soldier systems.

Firing the rifle in the stand-up version of the DSS.

Background

The Soldier Information Requirements Technology Demonstration project (SIREQTD) is examining capability enhancements for the individual dismounted soldier in 2010-2015. For many of these capability enhancements, building prototypes for field trials would be too costly in time and money to be feasible. The Dismounted Soldier Simulator (DSS) was developed to allow SIREQTD to investigate potential infantry soldier capability enhancements within a synthetic environment. The DSS can provide control of complex scenarios and comprehensive measurements without many of the costs and restrictions of field trials.



Section leader's view with inset UAV imagery.

Purpose

The DSS immerses an infantry section leader in a 3D computer-generated battlefield using a head-mounted visual display and motion tracking. This enables the soldier to accurately perceive spatial relationships amongst himself and the other soldiers and objects in the simulation. Proposed capability enhancements, such as future sensor systems, can then be added to the DSS and their effect on the section leader's comprehension, decisions, and actions in a variety of scenarios can be studied in great detail. The results of studies within the DSS can be used to identify tradeoffs between competing designs and to identify capability enhancements that should be advanced to field trials. The intent of the DSS is to allow

Dismounted Soldier Simulator

experimentation on the impact of future systems on the section leader's spatial understanding of the battlefield; it is not suited to addressing all SIREQ TD questions or all infantry actions.

Research capabilities

As the SIREQ TD experimental team poses empirical questions, the DSS can be customized to create the experimental conditions required. The DSS now provides one user with an immersive presence in the synthetic environment. Additional participants can operate desktop systems with similar functionality. Computer-generated forces can provide dozens of additional soldiers, vehicles, and aircraft that behave in a doctrinally representative manner. Currently, image intensification and infrared sensors are available. Weapons available are an assault rifle, light machine gun, grenade launcher, and anti-armour weapons. Video from UAVs, digital maps, text messages, intra-section video, and other data sources can be simulated and provided to the user in a variety of forms. Data monitoring, recording, and playback are supported and the system can be potentially networked to other simulators.

Desktop version of the DSS.

Simulated IR sensor imagery.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

DRDC Wound Dressings

Objective:

To develop wound dressings for treating traumatic injuries and post-traumatic complications encountered by front-line Canadian Forces casualties.

Background

Management of wounds sustained during military operations offers challenges that are different from treating comparable civilian wounds. For example, immediate wound care in the battlefield is normally not available and could be delayed for up to 8 hours, exacerbating the infection of the wound.

Avitar's proprietary polyurethane technology, one of the components of the DRDC dressing.

Furthermore, because wound care may need to be administered by the casualty himself or through a 'buddy' system, a simple, easy-to-use, all-in-one wound care management system is required. Lastly, the use of systemic drugs may not be recommended in wounded soldiers because of undesirable side effects that may be detrimental to performance. There is currently no commercially available medicated wound dressing that can simultaneously address these unique operational issues.

Development

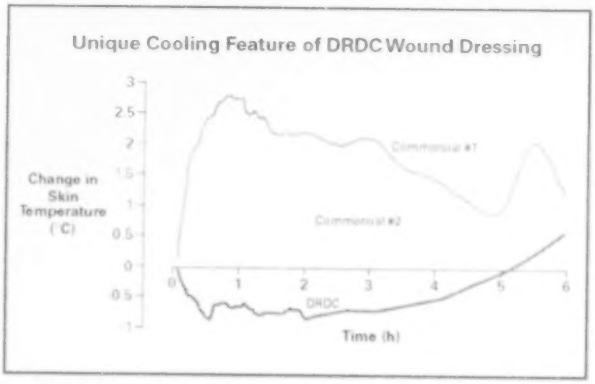
The development of a new wound dressing product began at DRDC Toronto in late 1999. A first-generation prototype was designed and tested extensively in the laboratory. Based on the novel product designs generated through this research, two patents have been filed by DRDC.

Current Status

In May 2002, DRDC Toronto signed a Collaborative Research Agreement with Avitar Inc. (Canton, MA) to

DRDC Wound Dressings

jointly develop a new generation of biomedical dressings for wound care. The objective of the 18-month collaboration is to produce a family of composite dressings for wound care utilizing the innovative product designs from DRDC and Avitar's proprietary polyurethane technologies. Avitar designs, develops and manufactures products for the healthcare industry and is a leader in the development of hydrophilic polyurethane foam products and applications. The new prototypes produced from this joint effort have already yielded very promising and exciting results in DRDC's initial assessment. Further assessment of the DRDC dressing will be performed in collaboration with the US Army Institute of Surgical Research.



The DRDC wound dressing cools the skin upon its application, while two commercial dressings were shown in experiments to increase skin temperature over the same period.

Attributes

The DRDC wound dressing has the following attributes:

- highly absorbent
- non-adherent
- flexible yet strong
- provides sustained therapy
- provides cooling
- inexpensive

Future directions

The next generation of DRDC wound dressings will be designed and produced for treating deep, heavily hemorrhagic wounds. This research is expected to be completed in 2005.

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Flight Surgeon's Course

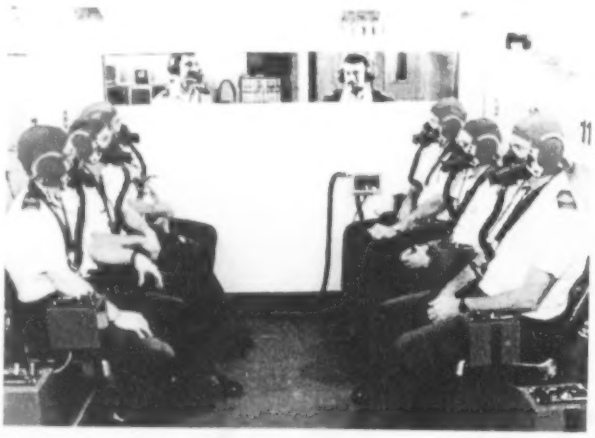
Mandate:

To provide Canadian Forces (and other) physicians with specialized training in the unique medical needs of aviators.

Background

Since the early days of military aviation, the unique medical needs of aviators have been recognized. In the early days of World War II, with the establishment of the School of Aviation Medicine, this recognition was formalized. After the war, the RCAF Institute of Aviation Medicine continued the tradition of training Canadian Forces (CF) medical officers in the treatment of aviators, acknowledging their expertise by awarding Flight Surgeon wings. This tradition continues today, at the School of Operational Medicine at DRDC Toronto/ CFEME, in the internationally renowned Canadian Forces Flight Surgeon's Course.

Canadian Forces Flight Surgeon's Wings.



Training includes high altitude indoctrination in DRDC Toronto's Hypobaric chamber.

Over 500 CF physicians have received Flight Surgeon wings since 1968. Other course attendees have included NATO medical officers, other foreign military doctors and civilian practitioners working in other government agencies such as Transport Canada's Civil Aviation Medicine Branch.

Course description

Objectives: The aim of the Flight Surgeon's Course is to train physicians in providing specialized medical support to air operations. Specifically, these physicians will be able to:

- provide clinical support to aircrew;
- provide environmental medical support to air operations;
- conduct Flight Surgeon duties in an operational air environment;
- support an aeromedical evacuation; and

Flight Surgeon's Course

- perform aircraft accident/incident investigations with respect to human factors causation.

Frequency: The course is currently offered once a year with a maximum enrollment of 20 students.

Qualification: This course meets the requirements for accreditation in Continuing Medical Education (CME) by the College of Family Physicians of Canada.

Training techniques

Academic: Lecturers for this intensive 32-day course include leading international investigators and practitioners in aerospace medicine. Students also benefit from the expertise of DRDC Toronto's research scientists.

Practical: Training is conducted using DRDC Toronto's unique facilities and equipment, including a human centrifuge, hypobaric (altitude) chamber, noise simulation facility (anechoic chamber), a Barany chair and a Gyro IPT (Integrated Physiological Trainer).

Operational: The course includes a week of flying familiarization at a CF base where each student gets to fly and live with an operational squadron.

DRDC Toronto's human centrifuge

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Diving Medical Training

Mandate:

To conduct and support diving medical training for Canadian Forces and other medical, paramedical and diving personnel.

DRDC Toronto's deep diving facility is used for training.

Background

DRDC Toronto's School of Operational Medicine (SOM) has conducted diving medical training for Canadian Forces (CF) divers and medical officers (MOs) since the 1970s. Advanced training used to take place abroad under the auspices of the US Navy. Because of the considerable length and cost of this training, as well as its emphasis on issues of limited relevance to the CF (e.g. nuclear submarines), the Submarine and Diving Medical Officer Course was created, with the first serial conducted in 1973. In 1982 the approach to diving medical training for MOs was revised, and the course was split into two phases – a basic and advanced course. Since then, 45 serials have been held and nearly 500 students trained to the advanced level. Over half were CF MOs, operational divers or paramedics, and the remainder were MOs from other nations or civilian physicians. As well, 700 medical and other operational personnel have received introductory training.

Canadian Forces Diving Medical Officer's Badge.

Course description

Courses: Current courses include the following:

- Diving Medicine – Basic (DMB) 2 weeks
- Diving Medicine – Advanced (DMA) 5 weeks
- Diving Medical Technician – Basic (DMTB) 2 weeks
- Diving Medical Technician – Advanced (DMTA) 5 weeks
- Clearance Diving Officer/Clearance Diving Technician (Diving Medicine segment) 3 weeks

Other training: Refresher programs for Ontario Provincial Police divers have also been held. SOM also

Diving Medical Training

advises on and assists with consultant-level training in diving medicine (conducted abroad) and contributes to civilian diving medical training through seminars, medical conferences and Certified Hyperbaric Technologist programs.

Current initiatives: Distributed refresher training for SOM graduates and the re-introduction of the Submarine Medicine Course.

Training techniques

Academic: Classroom sessions feature a wide variety of in-house and guest lecturers of international renown. Emphasis is placed on interactive case study discussions.

Practical: Students at all levels make a variety of open-water and recompression chamber dives, and are briefed on CF and other diving, submarine, and hyperbaric operations.

Future directions

SOM's diving medical training programs are continually reviewed and upgraded. As the centre of expertise in CF diving medicine, and the point of contact for 24/7 consultation, CFEME/SOM is well positioned to offer training that continues to meet current and future operational needs.

Students make a variety of open-water dives as part of their training.

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Centrifuge Training

Mandate:

To provide Canadian Forces (and other) aircrew with training that increases their awareness of the hazards of the high-G environment and enhances G-tolerance.

DRDC Toronto's human centrifuge.

Background

The Canadian Forces High Sustained G (CF HSG) Course was developed by DRDC Toronto in response to Air Command's increasing awareness of the need to prepare aircrew for the stresses of the High-G environment of modern high-performance fighter aircraft. The first formal CF HSG serial took place in June 1989. Mandatory attendance for all CF jet pilots was introduced in 1996. In the first eight years, 651 students were trained in 137 serials. Most students are Canadian Forces (CF) and Allied pilots of high performance aircraft, but pilots of other aircraft types and aircrew other than pilots also attend. The CF HSG Course is continually reviewed and upgraded according to the needs of the operators. Current initiatives under development include periodic refresher, upgrade and remedial training. Recent and continuing upgrades to the centrifuge facility itself have improved DRDC Toronto's ability to deliver a product to meet operational requirements.

Course description

Objectives: The objectives of the CF HSG Course are to provide life-saving insight into the hazards of the high-G environment and practical skills in methods of coping with it.

Training: This one-day course includes both classroom and practical sessions in DRDC Toronto's human centrifuge. Each pilot is given one gradual onset rate (GOR) and three rapid onset rate (ROR) runs. This enables student assessment, practice of the

Centrifuge Training

Anti-G Straining Manoeuvre (AGSM), and testing to an "Objective Profile".

Frequency: The course runs in direct response to demand.

Qualification: Students must demonstrate an adequate AGSM and pass the Objective Profile to receive the ITMIS AHQO qualification. The CF HSG Course conforms to NATO STANAG 3200 (HSG Training) and to ASCC Advisory 61/51, in addition to Air Command Order ACO-9-47-14.

Training techniques

Academic: Didactic and interactive classroom sessions cover hazards of G-exposure (e.g. G-induced loss of consciousness), physiologic responses to G-stress, and strategies for G-protection such as the AGSM.

Practical: Centrifuge runs include:

- a GOR run to establish the student's relaxed and straining G-tolerances;
- ROR runs to 4G and 5G to enable practice of the AGSM; and
- an ROR run to the appropriate Objective Profile (6G for jet trainer pilots, or 7.5G for CF-18 pilots, with a G-suit) for 15 seconds.

For more information

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DEFENCE R&D DÉFENSE

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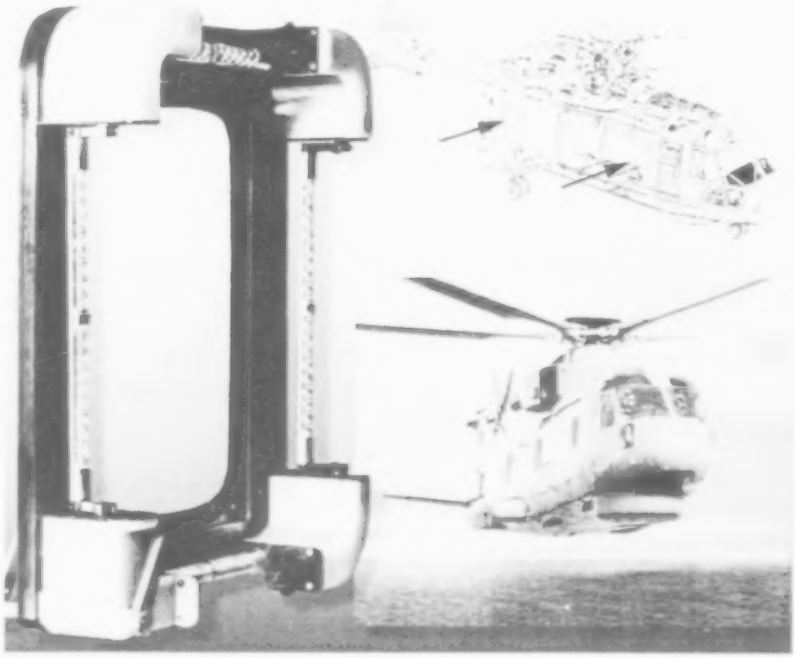
Universal Escape Exit for Helicopters

Objective:

To develop a universal mechanism to enhance the speed and safety of crew escape in helicopter ditchings.



Background

Helicopter accidents over water result in rapid sinking 50 percent of the time. Crew and passengers must escape as quickly as possible, especially in cold water where breath-holding ability can be less than 25 seconds.

One of the main causes of delayed escape is the lack of standardization in the location and operation of jettison mechanisms for helicoper doors, windows and hatches. A recent study[1] of 35 helicopter types found that there were 23 types of mechanisms positioned in many different places relative to the seated pilot or passenger.

Clearly, the Canadian Forces (and many others) have a requirement for a common escape mechanism that can be fitted into new designs of helicopters and retrofitted into current designs. In 1997, DCIEM (renamed DRDC Toronto in April 2002) proceeded to invent such a system.

[1]Brooks and Boheimer, Aviat Space Environ Med, 1977; 68: 844-57

Description

Under contract with Survival Systems Ltd, Dartmouth, Nova Scotia, a universal escape exit (UEE) has been designed for emergency escape through a helicopter door or window.

The UEE is designed so that the door or window can be released by pulling on any one of several bars (four on the window, five on the door). On water entry, all bars light up to outline the escape path. After the window is jettisoned, the lights in the bars strobe to indicate that the door or window has departed the helicopter. This alerts other passengers that the escape path is open.

The secondary method of activation – rotating a lever – overrides all the bars and jettisons

Universal Escape Exit for Helicopters

the door or window. This lever, which passes through the fuselage, can also be used for external rescue. If all else fails, the window can simply be pushed out using the bars as grip points.

Progress

A modular underwater helicopter escape trainer was used to assess the UEE prototype. More than 160 escapes were made by 48 subjects. The UEE was preferred over the Sikorski and Bell systems, and provided a critical two-second advantage in escape time. In a real ditching, this could make the difference between life and death.

Technology Status

US Patent No. 6,341,748 issued 29 January 2002.

Licensed for Commercialization to:

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Canada, B2Y 4K9

Tel: (902) 465-3888
Fax: (902) 465-8755
email: ssl@ns.sympatico.ca

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Spatial Disorientation Countermeasures

Objective:

To reduce the occurrence of Spatial Disorientation (SD) in the Canadian Forces through improved understanding of its mechanism and development of training programs.

Integrated Physiological Trainer (GYRO-IPT).

Background

Spatial disorientation (SD) is the failure to perceive correctly and unequivocally position, attitude, or motion with respect to the surface of the earth and the gravitational vertical. Operationally, it is the erroneous sense of magnitude or direction of the flight instrument based parameters. SD results from inadequacies of the human visual, vestibular and somatosensory systems in the aviation environment. Other factors such as G-transition effect, task saturation, distraction, restricted attention, the use of night vision devices and other image enhancing systems can also precipitate the SD phenomenon. A review of Canadian Forces (CF) aircraft accidents has identified SD as a contributing causal factor in almost 25% of all fatal accidents.

The objective of the SD countermeasure project is to reduce the occurrence of SD mishaps in the CF and the general aviation community by:

- improving our understanding of SD through research;
- developing SD training strategies for the CF; and
- developing models for predicting perceptual and sensory motor responses in flight.

Organization and resources

The SD project is conducted within DRDC Toronto's Aerospace Life Support Section. Research is translated into application through interactions with CF operations. For undergraduate pilot training, the GYRO-IPT (Integrated Physiological Trainer) is used to demonstrate selected disorientation profiles while in controlled flight. The GYRO-IPT is a flight simulator with a three axis (roll ± 30°, pitch ± 15° and yaw 360°) motion base and out-of-the-window visual scene. Disorientation illusions are limited to the inadequacies and ambiguities of the semicircular canals and the visual systems. The closed loop control capability creates an interactive learning environment since pilots must maintain control of the simulator while flying through the illusion to a successful resolution during their training. Visual scanning/point of gaze technology is used to investigate the pilot's scanning behaviour before and during recovery from recognised disorientation. Other rotating platforms and motion devices with six degrees-of-freedom are

Spatial Disorientation Countermeasures

employed to provoke specific altered gravitoinertial environments to study various motion adaptation syndromes including airsickness, simulator sickness and seasickness.

Progress

Research: The SD countermeasure team has expertise in human visual-vestibular interaction under simulated flight conditions, and in advanced techniques for studying the oculomotor, cardiovascular and autonomic responses under altered gravitoinertial forces. Various countermeasures for motion adaptation syndromes have been developed.

Training: The SD countermeasure team has made recommendations on SD training in the CF and facilitated the implementation of the Integrated Physiological Trainer in the undergraduate pilot training program and inflight SD demonstration sortie for the rotary wing. The team will investigate habituation transfer mechanisms in the desensitisation training of airsickness.

Future directions

Research: In addition to the visual and vestibular senses, SD research will focus on mental perception and confounding variables such as physiological and psychological states. Medical conditions that might increase susceptibility to SD will be investigated. The operational consequences of G transition effect, head-up displays, helmet-mounted systems, night vision devices and other imaging systems that might precipitate SD will be examined.

Point of Gaze Eye-tracker.

Training: A holistic approach to spatial orientation training is under consideration. The program will include academic instruction, realistic demonstration of visual and vestibular illusions, interactive simulator training, and in-flight training.

For more information

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DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

3-D Acoustics Research

Objective:

To enhance the effectiveness of auditory communications in Canadian Forces operations and training through the application of spatial (3-D) sound display technology.

Background

Conventional communications equipment such as the headphones and helmets used in Canadian Forces (CF) operations create "sound images" that are centered within the listener's head. However, research suggests that auditory reception can be greatly improved through three-dimensional (3-D) "spatialization." This technique enhances the realism of sounds by synthesizing the between-ear differences that result from the relative position of the head and ears in the original sound field. Responding to the processed signals, the brain recreates the 3-D sound image. Advantages claimed for 3-D audio are improved discrimination of competing voice messages and the ability to comprehend auditory warnings without the need for visual confirmation.

Organization

Research in this area is carried out by members of DRDC Toronto's Human Factors Research and Engineering Section.

Research capabilities

DRDC Toronto has developed an equipment suite for 3-D acoustics research that includes the following components:

- a computer-controlled test facility and sound isolation booth for studying the basic factors that contribute to the effectiveness of spatialized auditory displays;
- the capability to mount a variety of Head-Related Transfer Functions or HRTFs (the software implementation of between-ear differences) and to compare their efficacy in realistic task scenarios with human subjects; and
- specialized software to simplify the presentation of voice or signal stimuli and the entry of response data.

Applications

Current work involves the following areas of research:

- assessment of the performance characteristics of commercial headsets that contribute to the fidelity of spatial sound imaging;
- the enhancement of speech discrimination performance with existing HRTFs, and the

selection of the most effective algorithms for follow-on experimentation; and

- investigation of the extent to which exposure to adverse stressors such as noise and mental workload affect discrimination performance.

Future directions

Studies of the role of spatial sound in signal discrimination and comprehension will continue. The role of spatial sound in virtual reality (VR) training systems will be examined, with the goal of enhancing the fidelity of VR systems and improving transfer of training to real scenarios.

For more information

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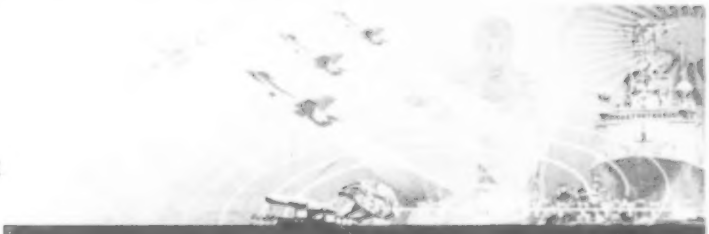

Defence R&D Canada – Toronto

Occupational/Public Health Hazard Assessments

Objective:

To anticipate, identify, quantify and recommend controls for health hazards associated with the occupational environment of the Canadian Forces (CF).

Baseline air quality assessments on Victoria class submarines.

Background

CF personnel are subject to a broad range of operational working conditions and may be exposed to hazardous materials or public health threats unique to the military environment. These include:

- Carbon monoxide and diesel fumes in armoured vehicles
- Carbon dioxide and low oxygen levels in submarines
- Contaminants in compressed air breathing systems
- Environmental or Industrial pollutants on deployed operations

Exposure to these hazards may compromise individual health and safety and lead to a reduction in CF operational effectiveness.

Organization and resources

Occupational/Public health risk assessments are carried out by the Health Hazards Group (HHG), part of DRDC Toronto's Operational Medicine Section. HHG members include defence scientists, laboratory technicians, occupational hygienists and preventive medicine technicians. This team is capable of conducting field surveys and trials on CF operations and weapons platforms, as well as developing biomarkers of exposure and new analytical techniques to identify and quantify the health threats identified.

HHG's Deployable Health Hazard Assessment Team (DHHAT) conducts health hazard assessments as part of any new deployed operation. It also conducts baseline monitoring on existing deployed operations.

Resources include state-of-the-art laboratory and field-portable instrumentation used to sample, assess and study a wide range of physical, chemical and biological hazards. This includes laboratory and field deployable Gas chromatography/Mass Spectrometers, HPLC, NDIR, FTIR and particulate analyzers.

Applications

CF diver's breathing gases: Quality is assured through an analytical program that uses the Gas Analysis Database System (GADS) developed and managed by HHG.

Submarine habitability: A detailed baseline air quality assessment will be performed on the new Victoria class

submarines to determine the effects of air purification capabilities, routine housekeeping procedures (cleaning and cooking), lifestyle effects, system effects (engine, compressor and motor), and the effectiveness of snorting. Research will be conducted on developing biomarkers of exposure using non-invasive methods to further quantify sailor exposures.

Armoured vehicle habitability: Field trials were conducted to assess the impact of new ammunition, weapons upgrades and vehicle modifications on crew compartment air quality. Research on non-invasive bio-monitoring techniques to better characterize the occupational environment is ongoing.

Tent group habitability: Health and safety assessments of cooking and heating equipment used during winter operations resulted in recommendations for future tent group system purchases.

Future directions

Future work by HHG and the DHHAT will include:

- The development of biomarkers of exposure for CF confined space environments (submarines and armoured vehicles) and other unique military toxicants (JP-8).
- Assistance with the development of an exposure tracking system for the CF that will monitor exposures to a wide range of hazardous agents.
- Development of personal exposure sampling capabilities; refinement and expansion of detection and analysis methods in support of health hazard assessments on deployed operations and weapons platforms.
- Advice to the CF on solvent, fuels, paints and battery off-gassing products as well as any new products used.
- Development of exposure guidelines for the Navy when conducting diving operations in moderately contaminated water.
- Development of technical requirements for field portable water purification devices for the Land Forces.

Air quality assessments in an armoured vehicle.

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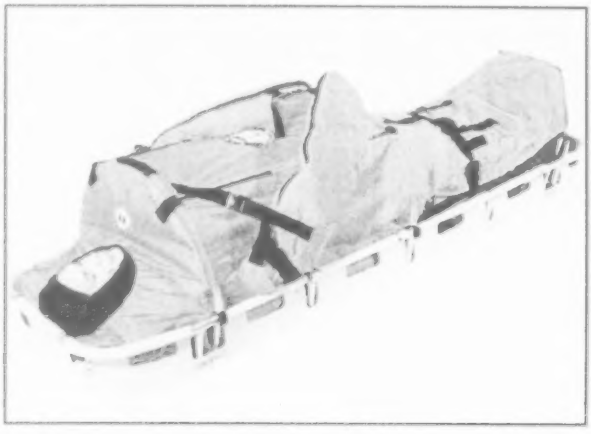
DEFENCE R&D DÉFENSE

Defence R&D Canada – Toronto

Field Rewarming System: the FAW

Objective:

To develop a portable system for the management of hypothermia casualties in the field.



Background

During rescue operations in remote areas, it commonly takes hours for Search and Rescue (SAR) personnel to transport casualties to a hospital for treatment. For victims of hypothermia, chances of survival can be optimized if heat loss is stopped – and hypothermia treatment started – both quickly and effectively in the field.

The few rewarming systems currently on the market use heated blankets or bags, heat packs, and/or inhalation of warm moist air to rewarm the victim. These systems have very limited efficiency and flexibility of treatment.

In conjunction with Mustang Survival Corp., Richmond, British Columbia, DRDC Toronto has applied its expertise in thermal physiology and protective systems to design a portable system for management of hypothermia in the field. DRDC Toronto's state-of-the-art Climatic Facility was used for development and testing.

Description

The FAW represents the first effective field-deployable hypothermia management system. It uses the principle of forced-air warming (FAW) applied to the torso and head regions. The warming treatment is complemented by the provision of warm intravenous (IV) fluid and warm oxygen (O_2) to maintain the systemic circulation and oxygenation of the victim during field treatment.

The FAW system can be integrated as an option to existing stokes litters used by SAR personnel. When not in use, it can be carried in a backpack.

FAW system features:

- an insulated dome which contains the micro-environment surrounding the torso and back of the head
- passive insulation for the limbs
- an insulated electronic warming system housed under the legs and powered by a small generator
- warm IV fluid and warm O_2 delivery systems
- a rugged wilderness transportation cart and backpack

FAW operation: After placing the victim in the system, the operator selects the appropriate heat setting depending on the severity of hypothermia: low (to eliminate body heat loss); medium (for slow

Field Rewarming System: the FAW

rewarming); or high (for more rapid rewarming, at approximately 5°C/h). The front and back of the torso, in addition to the back of the neck and head, are warmed by warm forced-air convection. DRDC Toronto's portable Vital Signs Monitor can be used in conjunction with the FAW system.

Applications: The FAW system was designed primarily for use by Canadian Forces SAR technicians inside the Labrador and the new Cormorant helicopters. However, it can be adapted for use in any emergency vehicle and can be used by ground SAR.

Status

Laboratory and field trials (in collaboration with SAR and the Canadian Coast Guard during simulated sea rescues) have demonstrated the effectiveness of the prototype. Field trials to evaluate the safety and effectiveness of the system under harsh conditions are planned. The FAW is ready for technology transfer to industry.

Patents Issued or Pending:

US Patent 6,409,745 B1
Canadian Patent Application 2,359,777
European Patent Application 01128885.9
Norwegian Patent Application 2001 6085

The FAW was designed for use inside CF helicopters but can be adapted to any emergency vehicle.

For more information

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